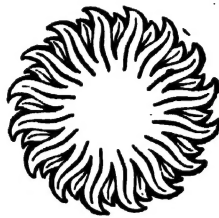


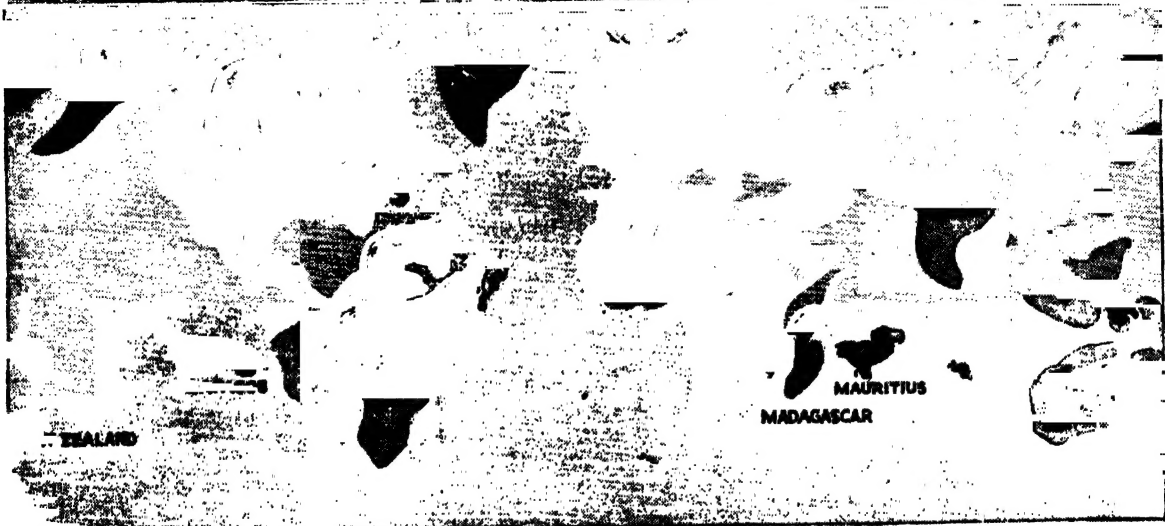
THE MIRACLE OF LIFE



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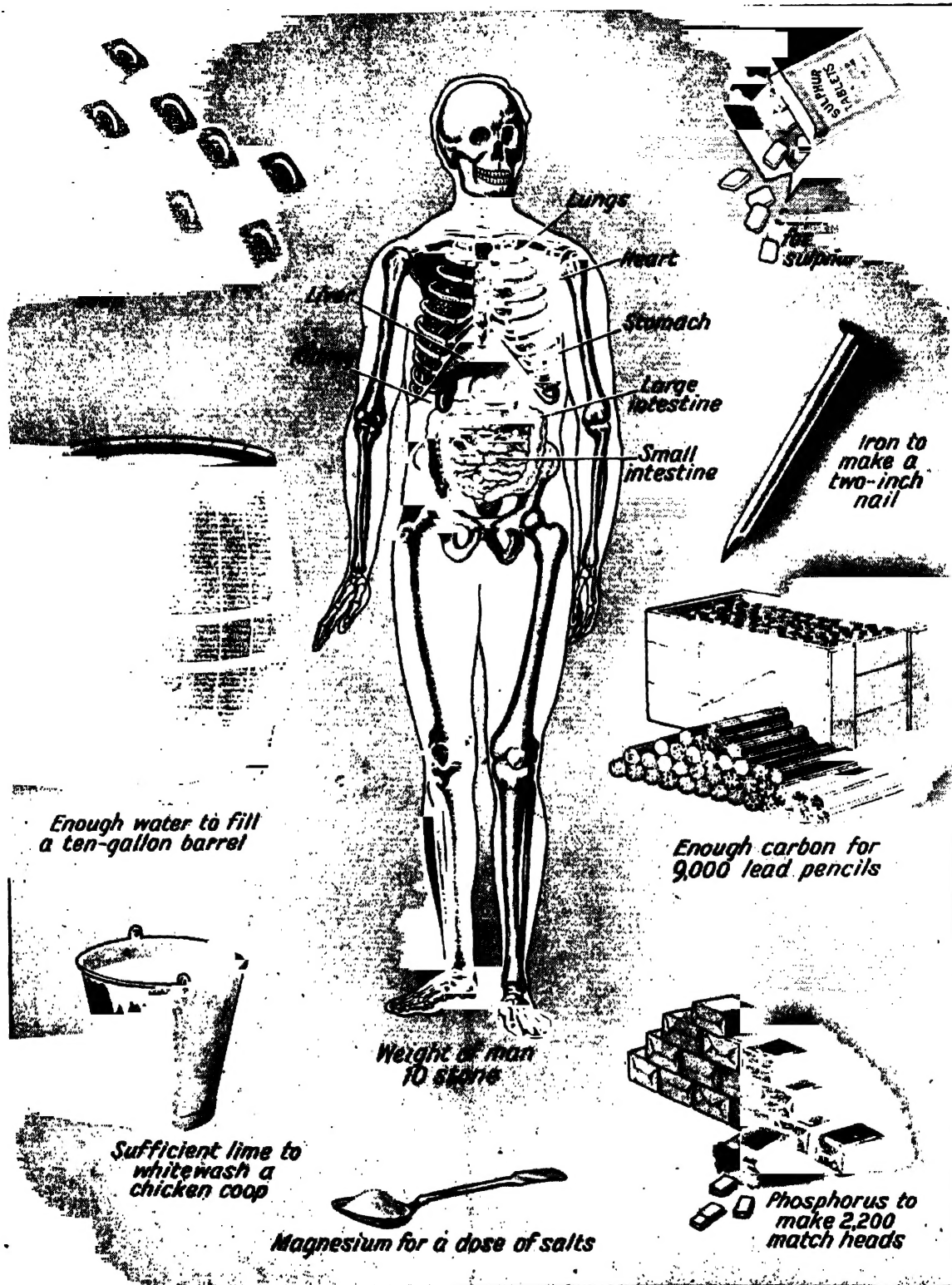


DISTRIBUTION OF CHIEF LAND MASSES AND CHARACTERISTIC ANIMALS

At the top of the page the main portions of the world are mapped as in all probability they appeared some ninety million years ago, in the centre as they were one million years ago, at the bottom as they are now.

CONTENTS

	PAGE
THE DAWN OF LIFE, <i>by L. R. Brightwell, F.Z.S.</i>	5
WHAT EVOLUTION MEANS, <i>by L. R. Brightwell, F.Z.S.</i>	9
EVOLUTION AS THE CLOCK TICKS, <i>by L. R. Brightwell, F.Z.S.</i>	25
THE ANIMAL KINGDOM, <i>by L. R. Brightwell, F.Z.S.</i>	51-184
CAMOUFLAGE AND COLOUR IN THE WILD	87
ANIMAL COURTSHIP	97
HOW ANIMALS MAKE A HOME	111
BRINGING UP A FAMILY	121
DURATION OF LIFE	127
FEEDING AND SLEEP	133
ANIMAL SOCIETY	147
ANIMALS IN RELATION TO MAN	165
THE PLANT KINGDOM, <i>by Alison Wilson, M.Sc., Ph.D.(Lond.), F.L.S.</i>	185-246
THE REPRODUCTION OF FLOWERING PLANTS	199
PLANT ANATOMY	213
PLANT BREEDING IN INFINITE VARIETY	229
PLANTS AND MAN	243
MAN'S FAMILY TREE, <i>by E. N. Fallaize, B.A.</i>	247
THE HUMAN MACHINE AT WORK, <i>by U. Philipp, Ph.D. and Susan Mercer</i>	265-316
DIGESTION AND EXCRETION	273
CIRCULATION AND RESPIRATION	279
REPRODUCTION	285
THE NERVOUS SYSTEM	289
SENSE AND SPEECH ORGANS	294
WHAT THE DUCTLESS GLANDS DO	301
THE CONQUEST OF ILL-HEALTH	304
INDEX	217



WHAT A MAN IS MADE OF

The chemical contents of a man weighing ten stone. It will be noticed that water, which consists of hydrogen and oxygen, is the chief constituent, namely about fifty-nine per cent by weight. The total cost of the various ingredients would not be more than a few shillings.



HYRID ANTARCTIC EXPEDITION II

BIRD LIFE IN THE GRIM ANTARCTIC

Life even penetrates the ice-capped wastes of Antarctica, though there are no land mammals. Among the few species of birds on the frozen southern continent are petrels and Emperor penguins, shown above.

THE DAWN OF LIFE

WITH the possible exception of the Poles, life is found on every portion of the earth's surface, and even for some short distance penetrating its crust. There is life, animal or vegetable, miles up the mountain side, and on the ocean bed miles below the surface. There is active life in the burning desert, and latent life, wanting only warmth to activate it, within a block of ice. Life in every conceivable form—the hermit and the herd, the giant and the pigmy—is on every hand.

Temperature is the dominant factor controlling life. Within the hot equatorial belt life swarms and multiplies in prodigal profusion; it decreases steadily, both in variety and in individual forms of expression, as we travel north or south.

Not that one needs to fly from Pole to Pole to appreciate the amazing richness of life. We can see its most startling extremes within the narrow confines of the village street. Here comes a shire horse back from work. He stands at the shoulder as high as an average man. One can almost feel the vibration made by his ton or more of bone and muscle as he leisurely

plods along the road. He stops, and plunges a hoof into a nearby pond. By doing so he disturbs a whole world of swarming life.

In the Natural History Museum of New York stands a glass case one cubic yard in size. There is always a crowd surrounding this case, and well there may be. No imaginative writer or painter, past or present, has ever envisaged anything like this exhibit, though many may have borrowed from it. It seems to combine the thrills of the liveliest jungle film with the eccentricities of the most outlandish dreams of Mars.

Here are trees and shrubs worthy of the coal forests, festooned with creepers of nightmare design. Within and around all these extravagances is seen a medley of living forms that make the plants seem ordinary by comparison. That the whole display is wonderfully presented in coloured glass—representing years of patient labour and research on the part of many men—adds still further to its dreamlike quality. It is this, coupled with the knowledge that the exhibit is a simple statement of fact and no mere invention, which doubtless holds tention.

THE DAWN OF LIFE

and excites the admiration of the motley gathering of human beings. For this exhibit represents one cubic centimetre of ordinary pond water!

Every day of the year our great libraries gather to themselves scores of volumes, pamphlets and other publications dealing with the visual world around us. But while every hour sees some former mystery explained, there still remains one outstanding question yet unanswered, though not of necessity unanswerable. How did it all begin? When we have traced life back through the records of the rocks, until we have come to its lowest denominator, a populace of minutest organisms neither plant nor animal, what then?

MYSTERIOUS BACTERIUM-EATERS

Life as we know it may one day emerge from the laboratory. The actual driving power which we call life is not essentially different from that operating the most obvious physical and chemical happenings of inorganic matter. Life differs from such only in its power to reproduce itself, and to reproduce itself over an infinitely wide range of conditions. It is not bound within the narrow limits

which are set to the building of a crystal or a mountain.

One of the latest theories regarding the origin of life relates to the action of bacteriophages or bacterium-eaters. A bacterium-eater is an organism about one ten-thousandth of a millimetre across. The fact that such a speck of life, or almost life, is too small to be seen by the most powerful microscope throws no doubt upon its actual existence.

NO LIFE WITHOUT SUNLIGHT

If some of the fluid from an outgrowth, such as a blister caused by foot and mouth disease, be sieved of all matters visible to the microscope, and the resultant fluid injected into healthy tissue, trouble follows. Something living, even though immeasurable, must be in the fluid, and that something has been named a bacteriophage. Such an inconceivably small entity can only thrive when living upon live bacteria. Then it multiplies exceedingly.

Scientists are still at variance as to precisely what a bacteriophage is. It cannot be called alive until confronted with a bacterium, yet it is not strictly dead. Possibly some such organisms, under the action of sunlight, which

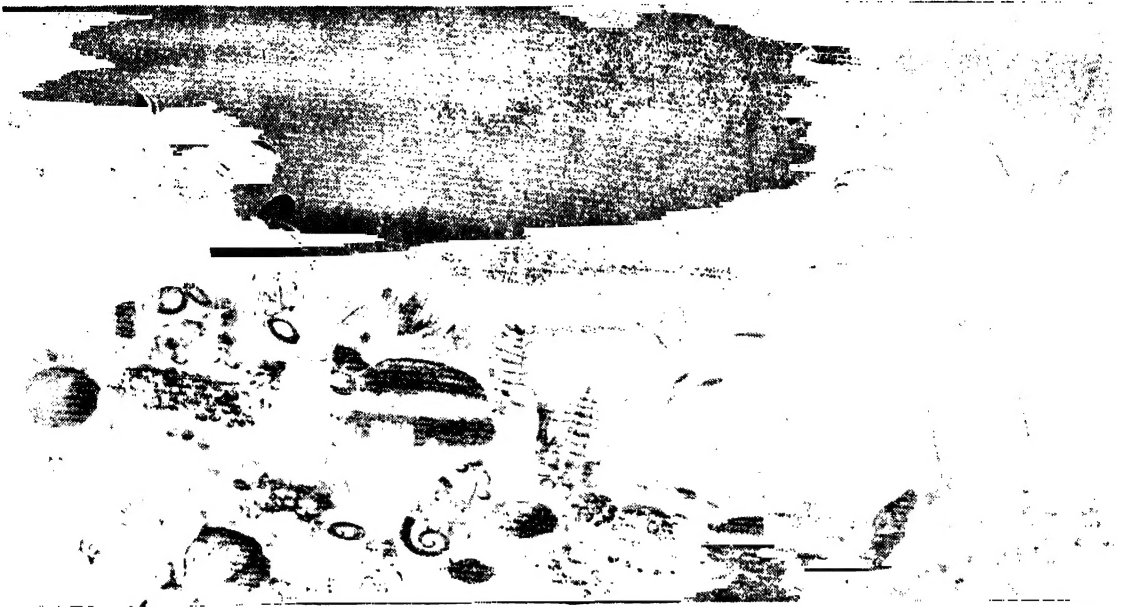


THE MIGHTY AND THE MINUTE

CHARLES A. HAMILTON

The extremes of existence can be appreciated within the confines of a village street, as when a horse weighing perhaps a ton plunges a hoof into a pond and disturbs a whole world of swarming life.

THE DAWN OF LIFE



MONDIAL

AT THE BOTTOM OF THE SEA MILLIONS OF YEARS AGO

Some of the common but varied types of life which flourished at the bottom of the sea during what is known as the Devonian Age. Reconstructed from fossils that were once living organisms.

ultimately alone makes any form of terrestrial activity possible, may supply the answer to an as yet unanswered question.

Napoleon thought that life itself was brought about by the action of sunlight on mud. Prof. J. B. S. Haldane has suggested that an ultra-violet radiation in the earth's early history might have led to the synthesis or combination of organic compounds of high molecular weight which might be an important step in the generation of life.

"The ether pulsates with life," writes Sir Oliver Lodge, "but we cannot perceive it. Life is revealed to us when it enters organs that for one reason or another are sufficiently receptive. The material body in which life is displayed to us may take many forms. Life is so eager to proclaim itself that it may just as easily assert itself in a flower struggling for existence on a refuse heap as in the person of genius."

GREAT MINDS DIFFER

"Though inorganic phenomena do not do so," asserted Lord Kelvin, "yet the phenomena of such living things as a sprig of moss, a microbe, a living animal—looked at and considered as matters of scientific investigation—compel us to conclude that there is scientific reason for believing in the existence of a creative and directive power."

On the other hand Sir E. Ray Lankester held that we cannot know "or even can hope to know or conceive of the possibility of knowing," whence the mechanism of nature "has come, why it is there, whither it is going, and what there may or may not be beyond and beside it which our senses are incapable of appreciating. These things are not 'explained' by science, and never can be."

WHAT KEEPS LIFE GOING?

The fascinating speculations of scientists such as those cited above deserve attention and study. As Dr. Julian Huxley has said, "To be impatient with the biochemists because they are not producing artificial microbes is to reveal no small ignorance of the problems involved. . . We rightly praise the skill of the chemists who build up dyes and drugs to order, but to build up living matters, substances as complicated as their highest achievements in synthesis would have to be used as the basic bricks. In any attempt at making living matter, we begin about where the modern organic chemist leaves off, and we begin more than a thousand million years of evolution behind contemporary living cells."

In attempting to deal with some of these primary matters in reasonable order, there occurs another question, the answering of which has involved a vast outlay in ink and

THE DAWN OF LIFE



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APOSTLE OF VITALISM

Henri Bergson, author of "Creative Evolution," and a winner of the Nobel Prize for literature.

considerable confusion of thought. Accepting the fact of life having started, what keeps it going? Above all, what keeps it going in the manner which it apparently does, on a gradually ascending gradient? Having established itself as a world populace of bacteria, why did it not stay there?

We shall see in due course how the simplest forms of life gave rise to ever more complex forms. The manner in which such marvels transpire can at least be studied in detail, and set forth in clear and systematic fashion. But neither evolution, nor the simple explanations offered by many creeds, savage or civilized, will satisfy all; the world holds too great a diversity of men and of thought.

BERGSON'S "VITAL URGE"

In 1907 there appeared a very remarkable book entitled *Creative Evolution*. The author was Professor Henri Bergson, a winner of the Nobel prize for literature and a distinguished member of the French Academy. *Creative Evolution* was an exquisitely poetic word-picture of the march of progress, beginning in the darkness of a new-born world, and ending with the emergence and

struggles of mankind. It crystallized the author's philosophy of life, which was that duration, change and movement are the only realities, that life is identical with time and change, and that we appreciate both, not with our eyes, ears, and possibly brains, but by intuition, whatever that, in this connection, may imply.

The author summed up *Creative Evolution* and its philosophy in the phrase *élan vital*. The vital urge or impetus explains everything—why potato plants do not produce pineapples, why a lion eats meat, why Jones becomes a bank clerk instead of a tight-rope walker. It is like being asked why a dog runs, and replying, quite well-meaningly: "Because it must."

THE ACID TEST OF SCIENCE

This same idea of a mysterious force making living things behave in their various ways, each according to its kind, has occurred to more than one philosopher. Mr. George Bernard Shaw showed it to us as "the Life Force" in the preface to his *Man and Superman*, published in 1903, and both the Life Force and the *élan vital* were interpreted over a century ago by Schopenhauer in his *World Will and as Idea* and *The Will in Nature*.

Such conceptions of life do not appeal to the scientist. He is concerned with facts alone.



SPENCER ARNOLD

INVESTIGATOR OF NATURE

Baron Kelvin (1824-1907) believed in the existence of a creative and directive power.



CHARLES R. KNIGHT (MONDIALE)

FORMER DENIZEN OF THE WILD

The mastodon, one of the many animals which have disappeared from the face of the earth. Mass slaughter, superior enemies and climatic changes have brought about the extermination of many species.

WHAT EVOLUTION MEANS

THE scientist, and perhaps most laymen, see the world as a place of trial and error, in which some learn and profit by their learning, while others fail and are forgotten. The lower animals are urged on by necessity; civilized man works deliberately towards a goal.

The conception of evolution as first publicly pronounced and widely disseminated through the writings of Charles Darwin is now part and parcel of every scientific worker's general belief, though few scientists are at complete accord with Darwin upon all the points he raised, nor in all probability will they ever be.

The average man accepts the idea of evolution much as he accepts the sunrise, and with considerably less understanding. Some of the old tags and catch phrases so freely used during the great Darwinian controversy still pass currency. To a large but probably decreasing number of people, the name of Charles Darwin stands for "the man who invented (or discovered) evolution," or "the man who said we came from monkey."

That Darwin did neither detracts nothing from the popularity of these scraps of misinformation. What Darwin, at cost of so much labour and research, did have to say on evolution is still as vague in many minds as what Mr.

Gladstone said in 1879, or at any other date.

Darwin was not by any means the first individual to appreciate that immense, unbroken series of natural phenomena which is summed up in the word evolution. He merely used the term as a convenient one to cover a general trend of events responsible for the forms and behaviour of plants and animals as we find them today, and believe them to have been in the past.

Centuries before the Christian era there were men who conceived the world around them, not as a haphazard dumping of ready-made plants and animals on the earth's surface, fixed and unchangeable according to their several patterns, but as part of an unrolling—a passing point upon an ever-unwinding curve. This is the true import of the Latin word *evolvere* (to unroll), from which is derived the term "evolution."

Some inkling of this can be traced in the writings of the Roman poet Lucretius, who lived about 98–55 B.C. The same thoughts, differently expressed, are apparent in the much earlier teachings of Empedocles (about 490–430 B.C.), Grecian physician and philosopher.

That astoundingly versatile genius Leonardo da Vinci demonstrated during the fifteenth century to the Florentine Court that fossils were



HAMILTON COLLECTION

ARTIST AND SCIENTIST

Leonardo da Vinci (1452-1519), who showed that fossils were the remains of prehistoric animals.

undoubtedly the remains of animals that had lived long ago, and which were, when alive, quite different from any creatures then in existence. The matter seems to have aroused no more than passing interest. But as the study of animals and plants, past and present, slowly increased, many minds conceived a quite different view of the world around them from that approved by the orthodox.

CHARACTERS ACQUIRED BY HEREDITY

Nearly three centuries after Leonardo da Vinci, Lamarck, the famous French zoologist, and Darwin's best known precursor, propounded the theory that the characters acquired by heredity were continually passed on, yet tended to change with changes in the individual's mode of life. Thus, the whale had apparently parted with its hind legs, much as the spider monkey had parted with its thumbs, from disuse. Every succeeding whale, though sprung originally from terrestrial stock, used what hind legs it had less and less, so these gradually atrophied or shrank; until whales were born with no hind legs at all. The law apparently held good even for accidental characters: a cat or a man, chancing to be

born with six toes, would be likely to beget progeny some or all of which might present the same superfluity.

Very soon after Lamarck's time, the Abbé Johann Gregor Mendel elaborated this principle by years of experiment, chiefly with plants, and established those broad generalities of heredity summed up in Mendel's law, or Mendelism. These are now regarded as bed rock by all similar experimenters, including the eugenisists, who advocate the scientific breeding of mankind.

LAMARCK STARTLES THE WORLD

Lamarck startled the thinking and still more the unthinking world, by suggesting that if characters acquired by use or disuse of certain parts were gradually handed on for long enough, there appeared another kind of plant or animal, a creature with specific characters marking it out from all others. This was the first blow to the school of thought which believed in a ready-made creation.

Contemporary with Lamarck was the Comte de Buffon, who turned the Jardin des Plantes, in Paris, from a wild beast show and den of necromantic herbalists, into the centre of



HAMILTON COLLECTION

NATURALIST AND WRITER

The Comte de Buffon (1707-1788), who reorganized the Jardin des Plantes, Paris, as a zoo.



RISCHGITZ COLLECTION

STUDENT OF HEREDITY

Gregor Mendel (1822-1884), whose broad generalities on heredity are known as Mendel's law.

scientific research and learning it is today. But the success of the reorganized Paris Zoo at the time depended largely upon the favours of Court and Church, rather than on the not too affluent scientists, and Buffon was shrewd enough to keep his views on evolution to himself.

Throughout the history of almost all human activities and beliefs it will be found that a host of workers may be engaged in the same field, often unaware even of each other's existence, and so continue for decades or centuries until one mind crystallizes the work of all, or at least supplies some vital factor hitherto missing, thus bringing about another and eventually universally accepted order of things.

POPULATION AND FOOD

During Lamarck's time an English clergyman, the Rev. Robert Malthus, was much engaged on a subject that is still causing anxiety to economists—that of population. According to him, the increase of the population was far in excess of the increase of available food supplies. In 1798 Malthus caused a sensation with his *Essay on the Principle of Population as it Affects the Future Improvements of Society*, in which he reviewed the whole question of man in

relation to food, and urged late marriage or abstinence as the only way to avert impending disaster. He talked of "the struggle for subsistence," which was apparently as pressing in leisurely 1798 as in the present hectic age.

This essay, repeatedly revised in subsequent editions, was widely read during the first half of the nineteenth century, and amongst thousands of others by two young men, Charles Darwin and Alfred Russel Wallace. Both had travelled widely as professional naturalists and acquired at first hand a vast amount of knowledge of the world of nature. Both felt that the Lamarckian idea of new characters being handed on by heredity supplied only a half-answer to the question of how the world comes to be peopled with such a multiplicity of ever-changing forms of life; both found in Malthus's mention of "the struggle for subsistence" the other half.

GO ON OR GO UNDER

Animals and plants, they argued, could not be just turned out like living machines by their parents, in very slowly changing forms, much as one gradually improves some machine-made instrument. They must be also moulded by circumstances, which always compel a plant or



RISCHGITZ COLLECTION

INFLUENCER OF DARWIN

The Rev. T. R. Malthus (1766-1834), author of a famous book on man in relation to food.

animal either to make the best of its environment or go under.

A living organism that survives conditions proving too much for many of its contemporaries will naturally tend to find an outlet for its reproductive instincts in seeking a mate of like



HAMILTON COLLECTION

FAMOUS FRENCH ANATOMIST

Baron de Cuvier (1769–1832), a vigorous opponent of the evolutionary theory of Lamarck.

virility. Thus parentage, urged by forces from without, hands on unconsciously its gifts to the succeeding generation, and so—very slowly it is true—new kinds of plants and animals come to pass.

This, in essence, is the meaning of the evolutionary theory as applied to living organisms. It is subject to much criticism and modification, but the broad facts of what is popularly and loosely termed Darwinism remain unshaken.

THE SURVIVAL OF THE FITTEST

Darwin, who had a true scientist's horror of half-formed and unproven theories, kept this conception of life's unrolling to himself for many years. Eventually he incorporated the idea in an essay of thirty-odd pages, which two years later (1844) became two hundred and thirty pages,

so rapidly had his knowledge and convictions grown. Fourteen years after this, Wallace, then in Malaya, sent to Darwin for criticism an essay he had written *On the Tendency of Varieties to depart indefinitely from the Original Type*.

The genesis of this essay is most interesting. For three years Wallace had puzzled over "the question of how changes of species could have been brought about." While down with fever in the Moluccas he was brooding on the ideas in Malthus's *Essay on Population* when all of a sudden there "flashed upon me the idea of the survival of the fittest." Ill as he was he thought out this new theory, wrote it down, revised his manuscript, and sent it off to Darwin—all within three days.

Darwin saw at once in Wallace's paper his own views only slightly differently expressed, and his generous nature was all in favour of according full honours for the realization of the truths contained therein to Wallace. It was only as the result of the utmost urging, almost coercion by eminent friends, that he gave to the world in 1859 his monumental work *On the Origin of Species by Means of Natural Selection, or the Preservation of Favoured Races in the Struggle for Life*.

"THIS MONKEY DAMNIFICATION"

The work was a best-seller from the first. Its publication gave rise to a controversy waged with a bitterness hardly credible today. To churchmen Darwin's case for evolution seemed a direct attack upon the Christian faith; many scientists could not bring themselves to believe that man was of the same ancestry as the lower animals, while the ordinary educated layman felt there was something degrading in "this monkey damnification," as Thomas Carlyle called it.

It was concerning the origin of man that the battle—to be renewed again with fresh vigour on the publication in 1871 of Darwin's *Descent of Man and Selection in Relation to Sex*—was waged most fiercely. The scientist, the layman and even the divine found, on the whole, little objection to the notion that a hornless breed of sheep might in time develop horns, or even that a semi-starfish, provided enough time were allowed, might eventually give rise to such complex and very different looking creatures as an ostrich and an elephant. Such theories were, indeed, already generally accepted.

But when it was suggested that man was of the same stock as the lower animals, was bone



SINGLE-CELLED WATER PLANTS THAT HAVE LIVED DOWN THE AGES

Diatoms are tiny water plants or algae with a single cell enclosed by two valves of silica. Some of the species, which number well over fifteen thousand, are identical with fossil representatives of the family.

of their bone and flesh of their flesh, and produced by the same gradual processes, the first shock of surprise gave way to indignation, and indignation to something approaching hysteria.

It was felt by all save the more pronounced "godless" scientists, that even if the other creatures were not the results of miraculous and cataclysmic creation, man certainly was. He stood alone, and to associate him with even a pedigree race-horse, far less a chimpanzee, was a direct insult to religion. Did not the Bible specifically declare, in the first chapter of Genesis, that "God created man in His own image"?

RELIGION v. SCIENCE

The Church took its stand on the Bible; Darwin along with an ever-increasing number of scientists (and, be it added, some theologians) took his upon the mass of evidence that he and others had collected to support his theory of evolution. Thus was originated the great and

unhappy, but entirely artificial conflict between religion and science.

Thomas Henry Huxley, "Darwin's bulldog" as he called himself, was one of the foremost to rush into the fray. The meeting of the British Association at Oxford in 1860 found the rival armies drawn up in formidable array, and a battle royal was waged in the halls of that ancient seat of learning.

BITTER CONFLICT

When the Rt. Rev. the Lord Bishop of Oxford (Dr. Samuel Wilberforce) sarcastically asked Huxley if he was related on his grandfather's or his grandmother's side to an ape, Huxley replied that he would not be ashamed to have a monkey for his ancestor, but that he would be ashamed to be connected with a man who used his gifts to obscure truth. Some time later Huxley wrote to a friend, "In justice to the bishop, I am bound to say that he bore no malice, but was always courtesy itself when we occasionally met in after years."

This is a restrained specimen of the exchanges with which public meetings, private converse, and the Press were full. The Ape versus Angels controversy, as some called it, was given an added flavour by the return from Africa of Paul du Chaillu the French explorer, who in 1856 discovered the gorilla, the largest



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POPULARIZER OF DARWINISM

Sir Edwin Ray Lankester (1847-1929). He did much to popularize Darwin's theories.

of the man-like apes. His highly-coloured stories of gorillas in the Gabun, though partly substantiated by actual specimens, were largely disbelieved and led to many stormy scenes. Once at the Anthropological Society he climbed over the benches and spat in the learned chairman's eye.

In reading accounts of that period one cannot fail to notice how many leaders of thought, even scientists, kept their science and their religion in watertight compartments. Some, like Charles Kingsley and Frank Buckland, great pioneers in popularising natural history, whilst admiring Darwin recoiled from the idea of evolution being applied to man, the one with hysterical, the other with half-humorous repugnance.

Professor Henry Drummond, a famous nineteenth-century Scottish evangelical writer, was typical of this mental outlook. Many years after the publication of Darwin's *Descent of Man* he replied with his *Ascent of Man* in which, combining his twin rôles of scientist and evangelist, he sought to dispose of the former work, substituting for Darwinism the theory that wild animals, by their care and consideration for each other, powerfully influenced "the survival of the fittest." Drummond's book proved, if it can be said to have proved anything, that the author kept his considerable knowledge of natural history in one tightly locked pigeon-hole, and his religious convictions in another. Under no circumstances were the contents of the pigeon-holes allowed to intermingle.

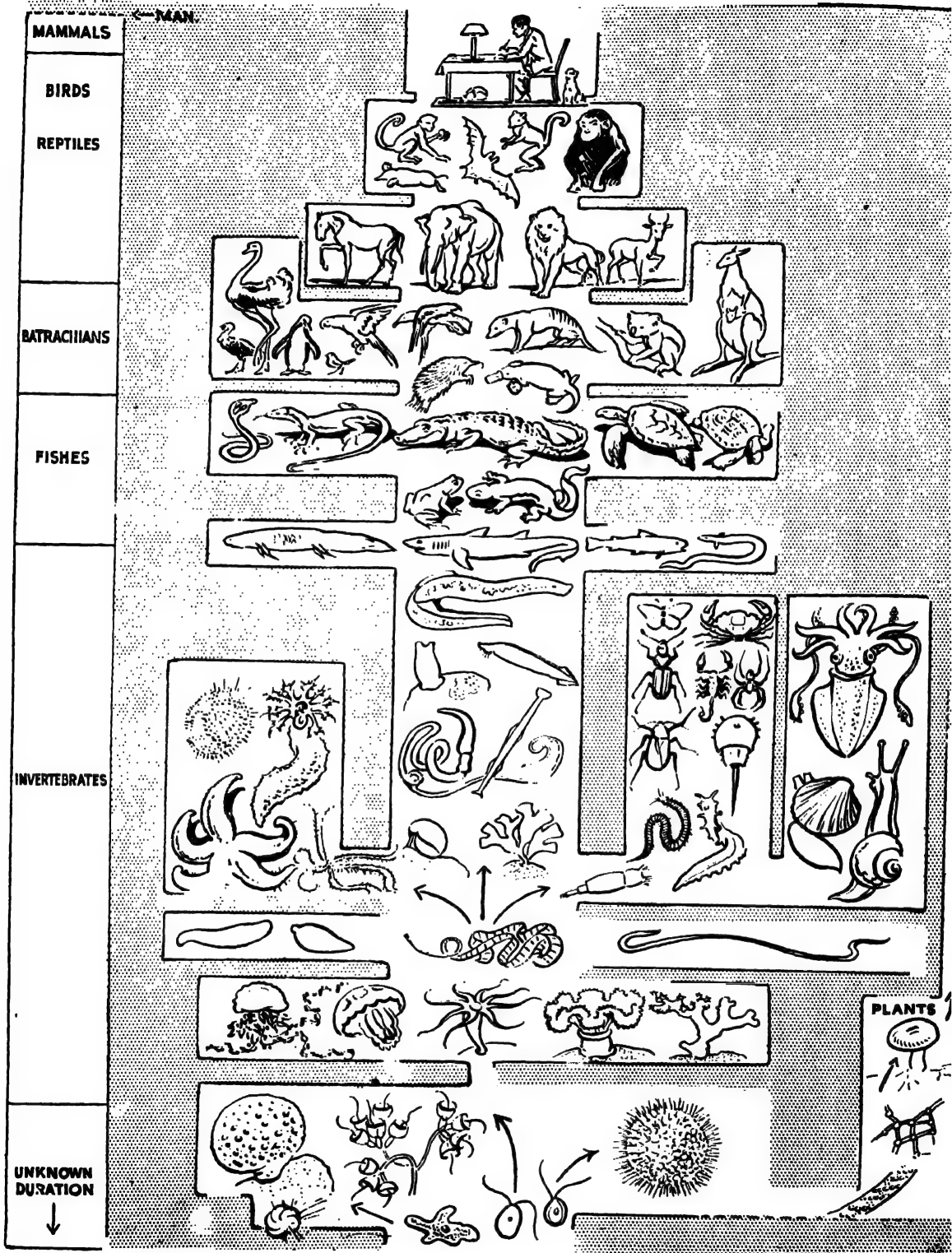
THE GORILLA SERMON

This was the attitude of most of the reading public for years, and echoes of those stormy days are still to be heard, though at lengthening intervals. Comparatively recently one of the best informed and most vigorously intellectual divines allowed some reference to the evolutionary process to creep into a sermon. A furious but short-lived outburst of almost Victorian intensity was the result, and even now a section of the Press refers from time to time to what it joyously named "the Gorilla Sermon."

More serious and still more grotesque was the sensation caused a few years ago in a little town in Tennessee, U.S.A. A too-progressive young schoolmaster rashly told his wondering class something of evolution. When his astonished pupils took home with them each his own version of "what teacher said," the ensuing hurricane eclipsed that which had once raged in Great Britain. The town in Tennessee put the rash young pedagogue on trial, whilst the more progressive section of the United States looked on agog, and hilariously nicknamed the unfortunate but eminently respectable township "Monkeyville."

When we remember the furore caused by such mechanical innovations as the railway and the first motor car, it is perhaps not surprising that we should be so reluctant to hazard the more serious adventures of the world of thought.

Though it does not appear to any great extent in either of his most famous evolutionary works, the *Origin of Species* and the *Descent of Man*, Darwin's study of living forms was bound

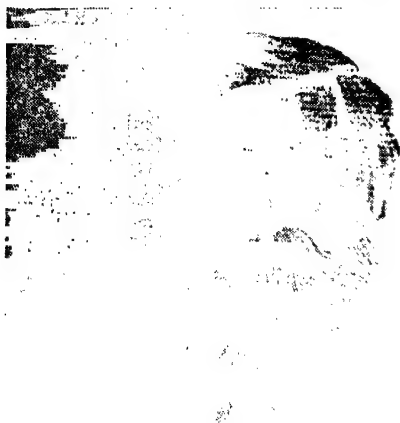


EVOLUTIONARY TREE OF LIFE

The approximate sequence of the main animal groups from amœba to man. Arrows denote the main directions taken by the various branches of the stem. The scale at left shows relative periods during which the groups arrived at fullest development, beginning with a time of unknown duration.

up with an equally detailed study of the innumerable creatures which are known to us now only as fossil remains.

Every modern zoologist and biologist now recognizes that an intelligent understanding of life as it is can only be possible if pursued in conjunction with a close survey of the life that was. The unborn puppy lives within its dam, as does the unhatched chick within the egg shell, through phases that clearly point to its original development from very different forms.



RISCHGITZ COLLECTION

ALFRED RUSSEL WALLACE

He thought out the idea of the survival of the fittest independently of Darwin.

In studying fossils one can trace back animal and plant existence through simpler and ever simpler forms, until in the oldest rock-formations we find ourselves back at the beginning—almost. We can, for the time being at least, go no farther. We are faced by the problem discussed in the previous chapter.

The earliest human records—drawings on the walls of caves—can be roughly dated as being some thirty or forty thousand years old. Written records are matters almost of yesterday. But what are commonly referred to as “the volumes of the Rocks” go back at least six hundred million years, and the information they contain, smudged and fragmentary as it is, points to a procession of plants and animals that, as regards sheer numbers of species, reduce existing species to a mere handful.

Our knowledge of the past grows daily, but in Great Britain it is garnered almost exclusively for the refreshment of the specialist. Little effort is made to popularize it, and the geological galleries of museums are usually a retreat for lovers or a haven for the drowsy.

England can show some amusing examples of how not to educate in geological matters. During the last two hundred years various charlatans have exhibited collections of bones strung together to form wonder beasts, and amassed fortunes in exhibiting them to a trustful public. Dinosaur and mammoth bones have been shown as evidence of men thirty feet high, and few have questioned their alleged origin.

BASED ON INSUFFICIENT KNOWLEDGE

In the early days of the Crystal Palace there was a passing fashion for prehistoric animals, and Waterhouse Hawkins, an architect who had long made the study of extinct monsters his hobby, originated a daring experiment. He erected a series of life-size effigies which still occupy a portion of the Palace grounds which was beyond the reach of the fire of 1936. The animals impressed everybody except the scientists.

Based on insufficient data, most of them are triumphs of absurdity. Richard Owen pointed out that the iguanodon, for example, had three and not five toes as in Hawkins's restoration, to which Hawkins replied that as they were toes and not corns they could not be removed, and there they are to this day. So enthusiastic was the sculptor that he took the moulds of his enormous creations, many of which were bigger than elephants, to America, with a view to setting them up in a public park. At the last minute the authorities broke up his moulds, not in view of their inaccuracy, but because they were “contrary to the accepted story of creation.”

MODELLED AS IN LIFE

Forty years after the Crystal Palace adventure, Pällenberg, a famous German animal-sculptor, undertook to make a similar group for Carl Hagenbeck's animal park near Hamburg. Whole skeletons were now available, whereas Waterhouse Hawkins had but a handful of bones; indeed, had he been content to resurrect only such animals as he really knew, his entire effort might have been as successful as his giant sloth, Irish elk and extinct tapirs. Pällenberg, having made miniature models of the creatures he proposed to show life size, took them on a

European and American tour, showed them to all the leading authorities on the remote past, and solicited their severest criticism. The result was the unique collection that is now at Stellingen.

The United States has also seriously undertaken to interest people in the world that was. Some museums, following New York's lead, have gone one better than Germany and show the extinct monsters not merely in self-coloured stone but clothed with hair or scales according to their kind. In New York every skeleton has a miniature model of the beast "as in life" beside it.

REBUILDING THE PAST

The artist has also been called in. One sees in a series of gigantic frescoes the mammoth herds tramping through Siberian snowdrifts, ground sloths as big as oxen on the sunny plains of the South American pampas, and scores of similar scenes into the past. They delight and instruct the man in the street, just as they satisfy the critical scientist. These models and pictures are statements of fact, not mere spectacles to invite a momentary thrill. How are they achieved?

Rebuilding the past is one of the world's



THOMAS HENRY HUXLEY

A stalwart believer in the theory of evolution, he called himself "Darwin's bulldog."



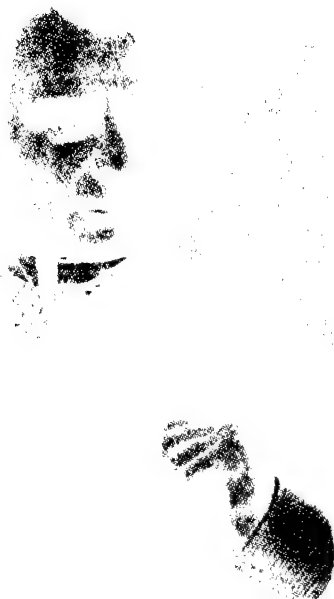
CHARLES DARWIN

His epoch-making work "The Origin of Species" was first published in November, 1859.

most expensive educational luxuries. When sufficiently generous sponsors have been found, a fossil hunting expedition sets out into the wild, perhaps for years. As in a trip to the barren tablelands in South Africa known as the Karoo, work may be possible only for a few months in every twelve. During the season of work the terrific heat, besides incapacitating many on the staff, exploded half the petrol supply and the scientists were faced with a premature return to civilization or death from starvation.

AIDED BY DYNAMITE

With its train of lorries and personnel, which may include hundreds of native porters besides expert naturalists, artists, plaster-workers, carpenters and camera men, a bone-collecting expedition suggests a belligerent army rather than a peace-time adventure. The collecting ground reached, there follow weeks of strenuous excavation with shovel, pick and dynamite. Often the bones of some giant beast, when finally unearthed, are so friable as to need swathing in plaster bandages. Small bones, bedded in a matrix of rock, may necessitate taking tons of solid earth to the museum, there to be sorted over months later. Assuming that all goes well, the work of a year or more may result in a



HAMILTON COLLECTION

CHARLES KINGSLEY

Although an admirer of Darwin, he recoiled from evolution as applied to the human species.

hundred-foot-long extinct lizard reaching New York packed in dozens of crates. Now the work of recalling the past may be said to start.

Each bone has to be cleaned and arranged, usually on the floor of a large hall or warehouse, in its proper position. The bones are drilled, wired together, and presently the dinosaur is hauled on to its feet by cranes, and its hips and shoulders supported by massive steel scaffoldings.

DRESSING A SKELETON

All being passed as life-like, there follows the clothing of the bones with "flesh." Usually a miniature model—one inch to the foot—of the skeleton is made, and a carcass of the nearest related reptile serving as a guide, trial muscles are made from wax or strips of brown paper and placed in their approximate positions. Each tiny knob and groove upon a bone has its significance. Dressing a skeleton may take a year or more. Finally the matter of scales, spines and so on has to be considered, and at last the monster stands complete.

Parallel to all this labour, other experts reconstruct from fossil fragments the plant life that must have been contemporary with the giant reptile, palaeographers decide upon

the nature of the ground the creature last trod, the approximate surroundings, and even the prevalent climatic conditions. Then, as in the vision of Ezekiel, do "the dry bones live," and the prehistoric past is resurrected.

The swiftest way in which any species can be exterminated is by mass slaughter. This has resulted within historic times in a still-growing list of creatures we can never hope to see alive again. Whole races of human beings have disappeared in like manner. Climatic changes have similarly obliterated not only hundreds of species of animals but whole races of them.

WHY SPECIES DIE OUT

Apart from the large numbers of creatures that at once succumb to climatic changes, there must arise the difficulty of a food supply which such changes automatically bring about. The customary food grows scarcer, and such as there is must be sought farther afield. Difficulties which few or none of the animals involved can cope with are encountered—changes of country, unforeseen and superior enemies.



SPENCER ARNOLD

SIR RICHARD OWEN

In his day one of the greatest authorities on extinct mammals, and a famous anatomist.



DENIZEN OF THE DEEP ONCE TERROR OF THE SEAS

MONDIAL

Restoring the fossil remains of an ichthyosaurus, an extinct reptile which lived in the sea. A full grown member of the species sometimes attained a length of forty feet. Work such as this may take many months.

In course of many years, scores of centuries perhaps, for the climatic change may be gradual, a few survivors have trekked far north or south, changed from cold to heat, arid land or swampy, or vice versa. Hairy creatures become less hairy, or pile on thicker coats. Other changes are in progress at the same time, until the original stock of beasts forced on the great hunger trek has died out altogether. The courageous few have kept on, begotten others after their kind; evolution is in progress.

TRAPPED BY TAR

There is evidence that extinction often came upon animals swifter than this. With stone-arrow-hurling men to harm them, whole herds of animals have come to a sudden end and dragged down others with them into shadowland. Many of their gigantic graveyards have come to light in recent years. One is the famous mastodon pit in Central Asia.

Here it is obvious that a race of strange elephants, with shovel-shaped lower jaws that hung close to the ground, browsed in peace, for many centuries no doubt, around the shores of an extensive lake bordered by a swamp. The

shovel-tusked, as they are called, apparently made deeper and deeper inroads on the swamp, digging up with their forked chins the lush vegetation that was their sole sustenance. Unknown to them, the lake was shrinking, and with it the swamp. There came a time at last, when, always reaching farther out for food, they foundered in the treacherous mud by scores, perhaps thousands, for naturally only the uppermost corpses, those of the last strugglers, have come to light.

Still more dramatic must have been the last scenes round the gruesome tar trap of La Brea, in California, U.S.A. La Brea is now one of America's chief sources of oil, and huge workings with offices and scores of dwellings, the outward and visible signs of human prosperity, surround the site of a prehistoric tragedy.

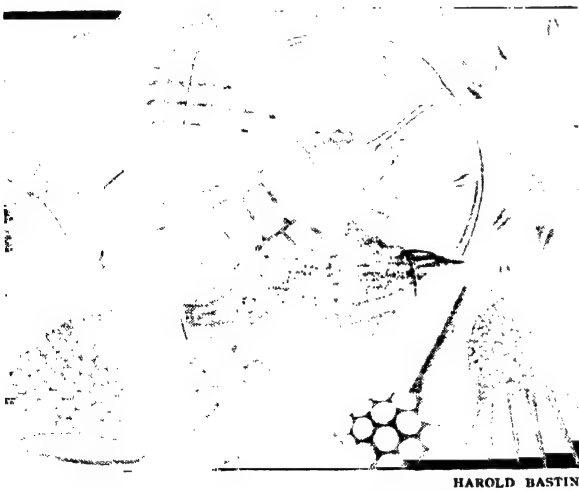
SANK TO THEIR DOOM

In this instance, thousands of animals came to their end, not as the result of food shortage but through drought. The now hard and safely worked asphalt beds were once fluid lava poured out from a volcano. In time the lava took on an appearance of solidity, and in the

slight declivities of its oily surface precious water collected.

All kinds of animals must have shown a reckless daring to reach this, just as they do now at African water holes when the dry weather sets in. First to the tar pools came ponderous elephants, ground sloths scarcely less massive and much less intelligent, gigantic bison, deer, antelopes, horses, swine, hares, rabbits, moles, shrews and even bats. As the blundering elephants and sloths sank to their doom, the sabre-tooth tiger sprang upon their helpless bulks to snatch a meal, and the wolf followed to dispute the feast.

Then from the surrounding pines and



FOUND FATHOMS DEEP

Vast areas of the ocean floor consist of the tiny but flinty skeletons of radiolarians.

cypresses came giant vultures to tear at wolf and sabre tooth, caught by the paws. All shared the same fate. The tar closed over their heads, until the scientist came to discover bare bones countless centuries later.

The tar thus took to itself over thirty kinds of large mammals and scores of small species, thirty kinds of birds of prey and over forty other species. Seventeen elephants were found in an area fifteen feet by twenty-five feet, and thirty-five feet deep. The entire animal life of the surrounding country was represented in this cemetery, which comprised beasts unlike any now living and others found today in far distant areas. Noticeably scarce were remains of the crafty bear, possibly the most cautious animal of that era.

The giant lizards of the Age of Reptiles, far more witless than the least intelligent mammals,

often died thus in mass formation, bogged beyond all hope of extrication. Sudden and local extermination may occur even in the sea. Thus in 1879 there was discovered in the Gulf of Mexico a peculiar species of tile fish which appeared to be abundant. Three years later ships reported large numbers of dead covering the sea surface for many miles in extent, the total death roll being estimated at approximately a billion.

The explanation offered was a prolonged chilling of the water through arctic currents driven inshore by north-easterly winds. The species was not seen again in any quantity until about thirty years ago. In 1894-95 the manatees of Sebastian River, Florida, were similarly all but wiped out by unlooked-for cold, while in the winter of 1920 New York lost almost its entire population of bluebirds, and Washington its fish crows.

TRUTH ABOUT FOSSILS

Thus it will be seen that cataclysmic happenings may all but remove a species at a blow. Volcanic eruptions pouring lava over land and poisonous gases into the sea, were more prevalent in the remote past than nowadays. But for the most part races and species have declined gradually, and sinking back into the earth from which they drew their sustenance have become converted, circumstances favouring, into the mineralized replicas of their former selves known as fossils.

The popular and incorrect definition of a fossil is "something that has been turned into stone." Silica, and certain combinations of lime or iron with sand particles do, in varying degree, mineralize various objects, but the scope for such fossilization is limited, and less common than one might suppose. Some things cannot be fossilized at all—the soft bodies of jelly-fish and anemones, snails, oysters and cuttle fishes, or the internal organs and muscles of vertebrates.

CASTS MADE BY MOTHER EARTH

Even bones cannot always be fossilized or preserved by time in any way. Mammal and still harder reptile bones preserve well, but not the air-filled bones of birds, or the partly ossified bones of fishes. When any creature dies on land where predaceous or carrion-feeding bone crackers abound, and the wind and rain and soil are brought to bear upon the carcass, the whole may be disintegrated before any kind of preservation can take place. It is matters such as these which make fossil collecting, and the



WHERE THOUSANDS OF BEASTS AND BIRDS PERISHED

The last scenes round the gruesome tar trap of La Brea, in California. The entire animal life of the surrounding country was represented in this cemetery when it was discovered countless centuries afterwards.

piecing together of the past, at once so fascinating and so tantalizing.

A large percentage of fossil plants, feathers, fish scales and other objects are no more than impressions or casts, made in much the same manner as the casts of a sculptor working with clay and plaster. Mineral matter closes in upon the object and preserves its shape, though the object itself entirely disappears.

MAMMOTHS IN ICE

Under favourable conditions a "modern" animal may die and in time its bones become fossilized, whilst the bones of an extinct creature like the great auk and dodo, or even a mammoth, remain relatively fresh. Mammoths have been found so well preserved in ice that the flesh has proved to be eatable. The so-called fossil ivory in London's dock warehouses is little different in constitution from that of living elephants.

An animal is most likely to be fossilized if it dies in a quicksand, or some quiet lake or estuary. Then as the skin and muscles disintegrate,

mineral matter gradually supplants every portion of the bony structure until, in the course of ages, every bone and even ossified tendons are fossilized in the fullest sense of the term.

The shells of molluscs and other creatures may themselves be welded together to form solid rock masses, like the oyster rocks at Tillywhim Caves in Dorset. The chalk cliffs of Great Britain are largely composed of minute shells of exquisite design, the foraminifera. Vast areas of the ocean floor consist, to a depth of many feet, of the so-called globigerina ooze, the tightly packed flinty skeletons of the infinitely small and very simple creatures known as radiolarians. The depositing of lime on solid objects by the famous hot springs of Auvergne, France, is not fossilization but incrustation.

TREASURES REVEALED BY THE SEA

Probably only a small proportion of the plants and animals which eventually go the way of all flesh is immortalized by fossilization, and of the millions that are thus preserved a smaller number still are unearthed by man. Only when



FRAMEWORK THAT SUPPORTED A BULKY BODY

The giant skeleton of a mammoth. Specimens of this animal have been found so well preserved in ice that the flesh has proved to be eatable. The so-called fossil ivory differs little from the tusks of living elephants.

the fossil beds lie relatively near the earth's surface, or are hurled up from below, or tilted up on edge can their treasures come within our grasp. Sometimes the sea or ice pares away a hillside till a cliff is formed, and then again we glimpse a graveyard of the remote past.

PREHISTORIC MARCH OF PROGRESS

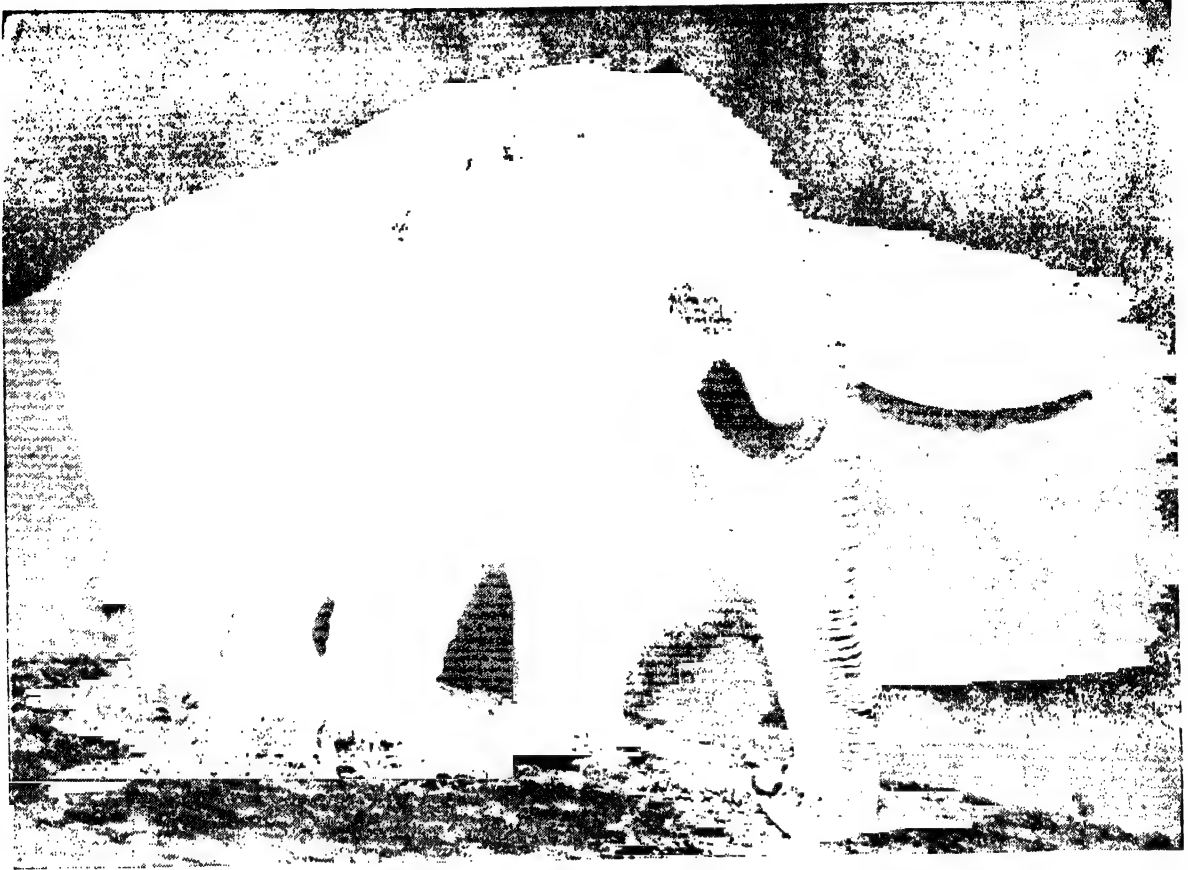
Even when thus thrust under our notice, the getting of fossils is often a tedious, even dangerous and costly process. But despite difficulties, and often scantiness of material, modern geologists and palæontologists may be congratulated on the pictures they have given us of a former world. In the ensuing chapter the panoramas of animal life are based on no vague guess-work. Fossils have furnished accurate records of thousands of different kinds of animals and the plants they lived amongst, and afforded clues as to how the creatures walked and sat, swam, flew and fed. Even the actions of wind and rain are sometimes set down for us

in the truly marvellous records of the rocks.

In arranging the long series of animal forms, one succeeding the other as revealed by rocks, it has been found necessary to divide the series into epochs, a term derived from a Greek word meaning "to check." The prehistoric march of progress is therefore marked off in epochs such as the Eocene or "dawn age," the Miocene or "less recent age," and so on. Each is calculated to cover a certain length of time in the earth's history, according to the age of the rock layers each epoch covers.

ROCKS ARE "RADIUM DATED"

The ages of the various rock formations can be ascertained with reasonable accuracy. This was only made possible by the discovery of radium in 1898 by Madame Marie Curie. The rocks are literally "radium dated." The first inscriptions of life upon their surfaces are traced back to between two and three thousand million years ago, and Nature is writing still.



THE MAMMOTH AS IT APPEARED IN LIFE

In 1937 it was reported that the frozen carcass of a mammoth had been discovered in Wrangel Island, off the Siberian coast. The animal once flourished in Great Britain, where remains have been found.

The marvels of mechanism and scientific discovery which the last few decades have seen are largely responsible for the progress now being made in recapturing the past. Prior to this fossils were mysteries to all save the learned.

STRANGE IDEAS OF THE LEARNED

It was once customary to believe that all kinds of animals could be spontaneously generated in mud or slime, so that their occurrence as dead remains in rocks was natural enough. They were merely creatures that had not succeeded in struggling to the surface, and succumbing, petrified. Theophrastus (about 372–287 B.C.), the Greek philosopher, observed of fossil fishes that they “either developed from fresh spawn left behind in the earth, or gone astray from rivers or the sea in cavities of the earth, where they had become petrified.” Even Aristotle (384–322 B.C.), the father of ancient natural history, looked upon fossils as mere curiosities.

The revival of learning in the sixteenth century gave a new meaning to the fossilia, the “things dug up.” Leonardo da Vinci’s pioneer work in this regard was confirmed a century later by Nicholas Steno, Professor in the University of Padua, but for long after this the deluge of the Pentateuch was accepted as the cause of death wherever fossils were discovered.

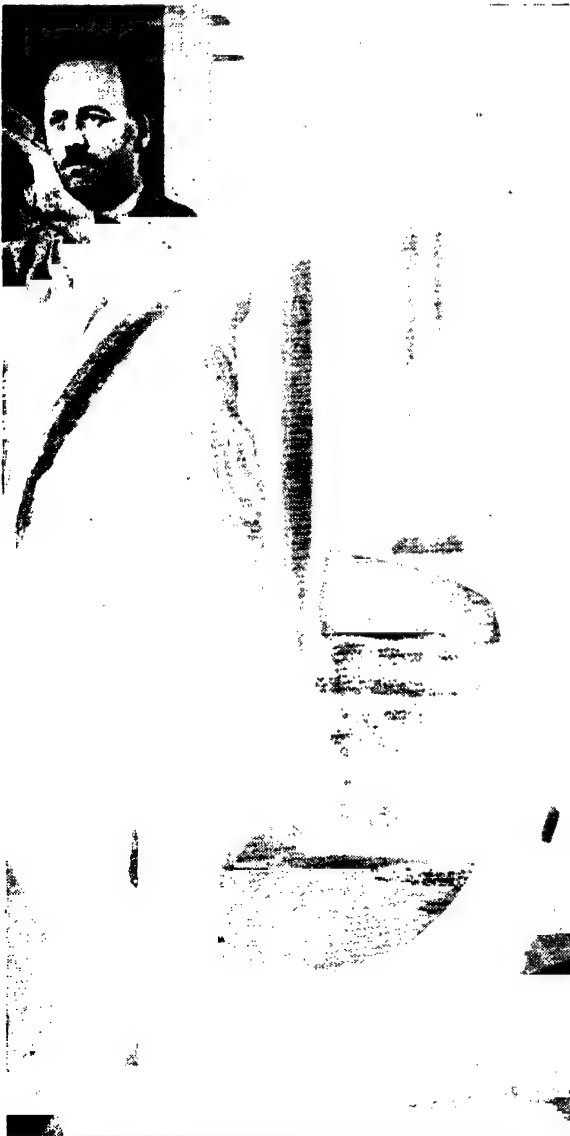
The real nature of fossils was fully appreciated in 1778, when De Luc coined the word “geology,” the science of the earth. From thence onwards a host of workers entered the field, and in 1834 H. D. de Blainville and Fischer von Waldheim presented the world with palæontology, now universally used to describe the science of ancient life—the reconstruction of the past.

SEA SERPENTS AND MONSTERS

To many people any review of the animal forms no longer extant seems like a nightmare, a piece of unreality. This, no doubt, coupled

with that human craving for the marvellous and sensational which is present, in varying degree, in nearly all of us, is probably responsible for the still popular belief in a sea serpent. It explains the popularity of certain films and such grotesque affairs as the Loch Ness Monster and the Nandi bear. The latter is worth recalling because at long last the beast was run to earth.

Before the World War and immediately after it, there appeared in the Press at intervals accounts of a horrid monster in Kenya Colony. It was half-man, half-hyena, walked erect, and had a passion for strangling women and children.



TUSK OF A MAMMOTH

Nearly fourteen feet long, this wonderful specimen was brought to London from Siberia.

So persistent were these rumours that the British Museum at last circularized all game wardens and other responsible persons in Kenya and the surrounding country requesting concrete evidence. Doubts began to arise when a newspaper reproduced a copy of the bear's footprint, which showed six toes. Experts resolved this into the footprints of two separate hyenas, one print superimposed upon another. Before long concrete evidence arrived in the form of skins and skulls, but these never matched. Sometimes a large hyena's skull was associated with a leopard's skin, sometimes the reverse was forwarded as belonging to one and the same animal. That is presumably the last of the Nandi bear.

DISCOVERING UNKNOWN ANIMALS

As for the possibilities of yet discovering strange and even huge monsters new to science, they increase rather than otherwise with our ever-improving means of exploration. Animals hitherto unknown are added to the list of ascertained forms at the rate of a hundred or so a year, but seldom attract the attention of any but scientists owing to their small size. They do not get a "good Press."

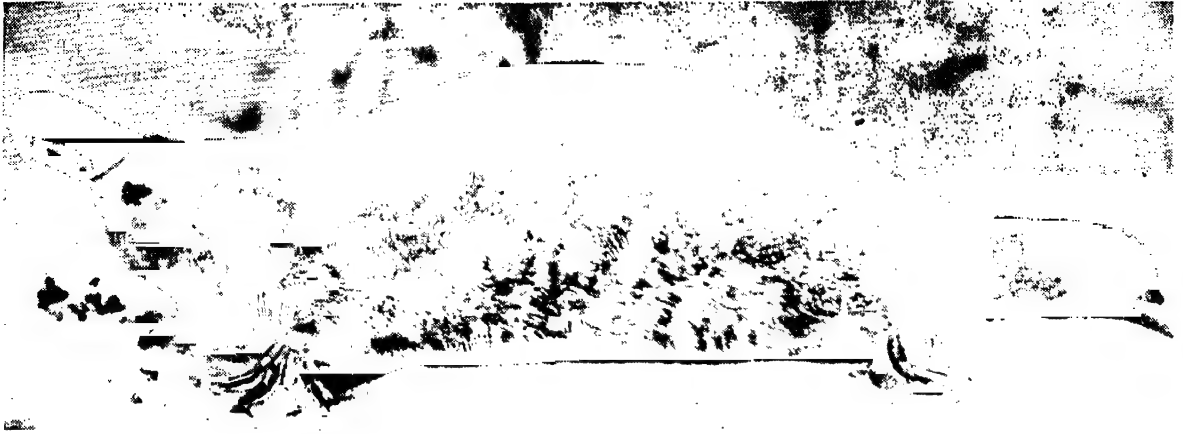
On the other hand, news of the discovery of the remains of an animal with which the public is familiar is invariably recorded in the newspapers. For instance, the finding of the frozen carcass of a mammoth in Wrangel Island, off the coast of Siberia, in 1937, received considerable space. Hair several feet long covered the whole of the body, which was in perfect preservation.

It is well to recall that only in 1897 a party of scientists stumbled upon an amazing cavern in Patagonia, where it transpired that primitive man must have herded ground sloths as big as oxen, and killed them for his table as occasion demanded. Fresh skin and even piles of dung belonging to the giant sloths were found, with other equally surprising matters.

AGE OF MONSTERS NOT PAST

Just three years after this disclosure began a series of baffling rumours which ended in the discovery of the okapi. Later the bones of the largest land animal yet recorded, a seventeen-foot high rhinoceros, were recovered from the Gobi Desert.

The age of monsters is by no means past, and as regards the highest animals, the mammals may yet be far from having reached their peak.



MOST PRIMITIVE AQUATIC MAMMAL

The Australian duckmole, or duck-billed platypus, is one of the most curious animals alive. It lays eggs like a reptile, suckles its young mammal-wise, burrows like a rodent and has a duck's bill and webbed feet.

EVOLUTION AS THE CLOCK TICKS

ONE may safely say that the broad principles of evolution as already touched upon are very generally accepted. No educated person today regards plants and animals as having simply "happened." It is realized that they are all part of a vast upward and forward movement, incidents in a world programme of continuous change, covering hundreds of millions of years.

It is the failure to accept or realize the immense periods of time marking the steps in evolution that largely militates against its general appreciation. The average man or woman simply cannot be brought to "think in millions." This is not surprising when we reflect that the momentous happenings of a single human life are compressed within the compass of some three score years or less.

How animal forms may change can be the better visualized if we confine ourselves to those creatures which man has taken under his charge during the last fifty centuries or so. Nothing that man touches remains unchanged for long. His restless energies, no matter on what they may be concentrated, make automatically for speeding-up. Often the impetus he gives to things astonishes himself. Take, for example, the animal with which man has been chiefly concerned—man.

The modern European, Chinaman and North American Indian present sufficiently obvious differences in their make-up, but these and all other races of mankind have enough in

common to justify their being scientifically included in a single species, *Homo sapiens*. Occidental and Oriental alike have a perfectly upright carriage, straight legs and a convex cranium. These features alone mark them off in strong contrast to the Neanderthal man of a million years ago.

The being whose remains were discovered in the valley of Neanderthal, Rhenish Prussia, to which place he is believed to have migrated from Syria, was unquestionably a man. He made tools and weapons, hunted, and roasted his food over a fire. But anatomically he presented features seen in none of the men who followed. He inclined to be below the medium modern height, had broad round shoulders and crooked legs. His nose was "squashed," his cheek bones were prominent and his chin receded. Above all, his cranium was flattened, far more so than that of the most primitive living bushman. By present standards he would certainly pass for human, but only just.

Mr. H. G. Wells has painted some rather startling pictures of the human race as it may be half a million or a few million years from now. In *The Time Machine* he portrayed the human race as having evolved upon two such divergent lines that the world knew only a subterranean breed of sub-human toilers, and a scarcely more attractive, though visually charming, decadent aristocracy. Other peeps into the future have shown us a human race freed from most bodily ills, through having

dispensed with much of its internal economy—appendices and other matters—and living largely on concentrated essences “enjoyed” via the medium of a hypodermic syringe.

Another view has shown a race in which the growing tendency to specialize has been carried to extremes, giving us a world of giant soldiers, four-handed sailors, chemists with huge noses, road workers with arms like those of a gorilla, messengers and jockeys little larger than dwarfs, and so on, till the mind reels. None of these glimpses of our future has yet been realized. Yet the fact remains that man has

two and a half inches and fourteen and a quarter pounds.” This is consistent with the general trend of evolution. Almost every branch of the animal kingdom has had its hey-day, has risen to a summit, and developed to its fullest capacity.

It would be hazardous to say that man has necessarily become more intelligent during the last few hundred years. The world still awaits another Shakespeare. But the brain case tends perhaps to increase; there would be some difficulty in finding a “fit” amongst early helmets.

OUR DEGENERATE LITTLE TOES

Our quite unnatural clothing and varied artificial diet are working other changes in our make-up. There is an increased tendency to bodily hairlessness and amongst males, at least, to baldheadedness. Dental ailments are increasing, and there is a tendency for our back teeth to be crowded out; future man may have less than the accepted complement of thirty-two teeth. Footwear is making its imprint on our toes. The little toe is fast lapsing into a state of degeneracy, and a few million years—much less perhaps—may see man a four-toed animal.

Yet man with all his clamouring for variety is a conservative animal. He persists moreover in directing his own affairs, and anything like scientific breeding of human beings on lines laid down by accepted authorities is still, fortunately or otherwise, a long way off. Where domestic animals are concerned, we see evolution being speeded-up at an astonishing pace. The strange fruits of modern “artificial selection” are instances of evolution—within the literal meaning of the word.

DOGS OF RECENT BREED

In no creature is this more apparent than the dog, perhaps the most malleable of all mammals. Some of our accepted breeds are of great antiquity, but many are of quite recent growth. Prior to the founding of the Kennel Club in 1873, dog owners generally were content with a few “serviceable” breeds, for guard or hunting purposes. When the first dog show was held at Newcastle in 1856, only about a dozen breeds were recognized. Today nearly a hundred separate breeds are “benched” at all important shows.

This semi-scientific cult of the dog has rung incredible changes on the canine form as generally accepted. The fancy has fixed on



BRITISH MUSEUM (NATURAL HISTORY,

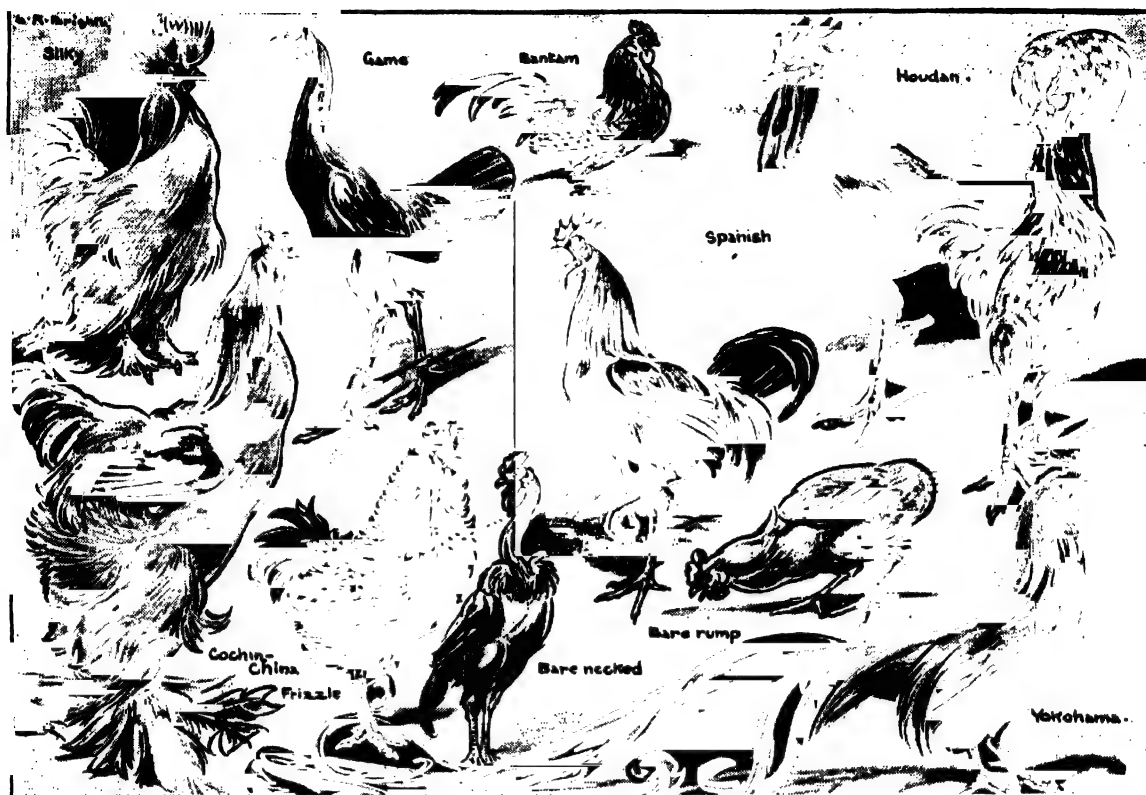
ONLY JUST HUMAN

A skull of this type was first found in the Neanderthal Valley, Prussia. Its owner made weapons and roasted food. No living race is so primitive.

undergone some visible changes within the last few centuries.

Man is bigger than he was. The average individual finds it difficult to squeeze into some of the earlier suits of armour. The man of tomorrow will be even bigger. Thanks to the recent care given to problems of nutrition and physical education, the present generation of children shows a marked increase in size and weight over those of the last.

“The average boy of fourteen,” reported the School Medical Officer for Sheffield in 1937, “shows an increase over his forerunners of three and a quarter inches in height and nineteen and a half pounds in weight. Girls of fourteen show, on an average, an increase of



VARIETIES OF DOMESTIC FOWL

Artificial selection in the breeding of poultry has produced some extraordinary results. Certain features have been developed to fantastic extremes, as can be seen in the tail of the Yokohama fowl and the leg-feathers of the Cochin-China.

certain features in a breed, and often developed them in the face of all accepted standards of art and even humanity. The Kerry Blue, Griffon, Yorkshire terrier and others can scarcely see through their lavish suits of hair; the show-bench greyhound is useless in the field, the bulldog can scarcely breathe and its disproportioned head renders its birth almost a death warrant to its dam. Of late years there has been a certain revolt against the production of monsters, and there is an increasing tendency to award prizes for general intelligence.

CHANGES IN CATTLE

Domestic cattle have also undergone surprising changes in a short time. When the famous Smithfield Club, the world's oldest cattle-breeding society, was founded in 1798, a prize ox weighing some four hundredweight would stand over five feet six inches at the shoulder, and would be a mountain of fat. Four years were required to attain this standard of "perfection." Now a champion steer will still weigh four hundredweight, but be only

two years old, stand not much more than four feet high, and be a compact mass of nutritive beef, in other words flesh from head to tail.

The world of the poultry and pigeon fancier runs the canine cosmos close in extravagant and unreasoning excess. As regards pigeons, man the creator has produced the fantail, unable to walk properly; the tumbler, incapable of straight flight; the tottering pouter, nun and jacobin; and the dragoons and trumpeters, birds whose bills bear a mass of tumorous fungus flesh outweighing the head itself. Other breeds again have such heavily feathered legs that specially constructed cages must be provided for their accommodation.

ALWAYS STARING UPWARD

Poultry has similarly been at times "improved" with little regard for utility or the birds' comfort. The limit in grotesqueness is reached by the Japanese game fowl, or Yokohama. The tail coverts of a prize cock may measure between twenty and thirty feet in length. Such a bird lives its life perched at

the top of a cylindrical cage, and is exercised daily on a perfectly clean floor, with a train bearer in attendance.

A creature, it may be noticed, suffers in exact proportion to its responsiveness to the evolutionist's dictates. One final example may be quoted—the goldfish. For many centuries past China, land of its origin, has been "ringing the changes" with wonderful results. Thus we have the veil tail, floating in a gossamer cloud of its own fins, some of which are duplicated. The tumbler suffers from



WIDE WORLD

VEIL-TAILED GOLDFISH

Ingenious breeders have been experimenting on the goldfish for many hundreds of years in China, their original home.

spinal curvature and rolls head over heels in the course of its progress. The telescope-eyed fish suggests a piscine snail, and the star-gazer stares from birth to death at the surface above. The egg-fish has been shorn of most of its fins, and the lion-head suggests permanent mumps.

Many of these abortions are the direct results of deliberately perpetuating deformities caused in the first place by breeding under the worst possible conditions. A staggering example of oriental ingenuity is seen in the Japanese waltzing mouse. By breeding in the first place from mice suffering from cerebral disease there has come to pass a strain which now punctuates all its doings by plunging at a moment's notice into a frenzied dance. In the midst of play, feeding, or even sleep the urge to waltz may come upon the animal, and it revolves nose to tail with fast accumulating speed, until it literally becomes an animated wheel.

For reasons not yet fully understood, animals vary much in their responsiveness to "accelerated evolution." The slim race-horse and the massive shire or percheron, whilst sufficiently unlike the ancestral type, still living in Mongolia, are recognizable as creatures evolved from some common stock. The same could scarcely be said of the greyhound and the pug. In like manner the guinea pig, rabbit and—to instance a domestic bird—the turkey have not greatly altered, in essentials, from their wild ancestors.

CONSERVATISM OF THE CAT

A yet more striking case of conservatism is presented by the domestic cat. Hundreds of distinct breeds may be listed by the "fancy," but under their skins they are all much alike. Apart from the tail-less Manx, domestic cats, despite centuries of "improvement," chiefly differ only in the quality and colour of their fur.

Artificial selection, it may be further noted, must be the subject of ceaseless care and supervision, or Nature, asserting herself, will, so to speak, reclaim her own. The processes will be reversed, and the creature throw back to its original form.

This was once amusingly demonstrated. Many years ago a delegation from Madagascar was touring Europe, and amongst the many marvels brought to its notice was the goldfish. So delighted was the delegation that it took back to Madagascar a large consignment of the wonder fish, and gave them the run of home waters.

ANIMALS THAT REVERT TO TYPE

The result was disappointing. Within a depressingly short time the goldfish, finding little fighting spirit amongst existing native fish, ate them up and became lords of all they surveyed. Moreover, the tendency of artificially selected animals to "throw back" to the ancestral type asserted itself. Slowly they slipped back to the drab livery of the wild carp, from which their race had originally sprung, and the goldfish that were to have enlivened all Madagascar were soon nothing but a memory. An importation of additional goldfish, unless on a grand scale, would probably not have checked "reversion" in the long run.

Up and down the world, on the great land masses and innumerable obscure islands, we meet with pigs, dogs, cats and other animals that have similarly slipped back to a wild or



FANTASTIC TELESCOPE-EYED FISH OF CHINA

WIDE WORLD

A striking example of the goldfish breeders' efforts at speeding up evolution. Another type, appropriately called the star-gazer, stares from birth to death at the surface or the sky above.

semi-wild form. This is ever the way of a domesticated animal unless man deliberately and unceasingly directs it along the special lines he desires.

One of the chief stumbling blocks which still hinders the general appreciation of evolution is the apparent disconnection between the main groups of the animal kingdom. Up to about thirty years ago the public was continually crying for "missing links." The discovery of the Java ape-man and other semi-human creatures seems to have somewhat relieved the general anxiety. It is still, however, far from widely realized that every animal is a link in the chain of life, and that between almost all the main groups of living things are to be found creatures that serve to join one to the other, by merging the characters of both.

MAN'S SPINELESS LINKS

Take for example, what most will feel to be a much-needed link, one between backboneed creatures like ourselves, dogs, birds, reptiles, fish and so on, and spineless creatures such as lobsters, oysters, worms, and the insect hosts. There are plenty of links between these two so widely contrasted groups; they are to be found all over the world. All round the coasts of Great Britain are to be seen the curious

soft-bodied creatures known as sea squirts. They hang, like gelatinous bladders, from caves and harbour piles and encircle shells and seeds.

Readers who have visited the famous cave in the Roches Douvres at Jersey, will appreciate Victor Hugo's description of the place when he said in *Toilers of the Sea*, that "the walls were splashed with crimson stains, as if giants had been fighting there." In some restaurants in the same island what look like large and very unattractive potatoes are sold as "violets of the rocks." Both these and the crimson stains in the Roches Douvres are sea squirts, creatures apparently as far removed from ourselves as one could well imagine.

INTERNAL ORGANS THAT DISAPPEAR

When it emerges from the egg the sea squirt is a minute but well formed, extremely lively tadpole, and save for its small size and that it has but one eye, might reasonably be expected to develop along lines approved by the frog. It has in particular a well defined central nerve cord, just like that of a vertebrate. Yet after a few hours, or at most days, of active independent life, it undergoes an extraordinary transformation. The suckers on its head, features it shares with the frog tadpole, it attaches firmly to a rock or other anchorage,

and so stays poised, tail upwards. Then one by one its internal organs literally "fade out," though the creature itself increases steadily in bulk.

By the time the creature is fully grown—and some sea squirts reach a foot or so in length—it is little more than a stomach into which food is swept by minute but ceaselessly lashing hairs. Edible particles are carried in through one simple aperture, and waste matter is washed out through another. Indeed the creature lives



HAROLD BASTIN

ANCHORED FOR LIFE

Within a few days of birth the sea squirt changes from a tiny tadpole into a large formless mass.

much as do the oyster and pond mussel, and like the former is anchored for life without the slightest capacity for further directing its destiny.

In the Channel Islands, and on many tropic beaches, the fisherman when digging for bait often finds a strange worm-like animal which unfortunately has no more homely name than *Balanoglossus*. It varies from a few inches to several yards in length, according to species, often advertises its presence by a powerful odour of iodoform, and like the earthworm feeds by simply passing a non-stop stream of mud throughout its entire length, retaining only minute edible matter in transit.

Like the sea squirt this weird animal is an important link, for its nerve cord not only shows close resemblance to that of the

vertebrates, especially in the unborn stages of development, but its eggs hatch out into larvæ very like those of sea urchins. Many naturalists mistook them for such until, by keeping the minute creatures alive, they found to their astonishment that they turned into something very different from the familiar "sea egg."

The shrimp trawl sometimes brings on deck a transparent animal about two inches long, looking rather like a laurel leaf made of glass. This is the lancelet, which scientists called "the sheet anchor of the evolutionist" before it was recognized that everything living is similarly a sheet anchor.

HAIRS AS FOOD GATHERERS

The lancelet at first develops on lines very like those of many worms, but it ends up not unlike those crude "almost-fish" the lampreys. It has the first beginnings of a spinal column, but made of gelatinous stuff, as in the lampreys, and it has no true mouth with jaws and teeth such as only vertebrates possess. Instead food is swept into its inside by lashing hairs surrounding a small opening.

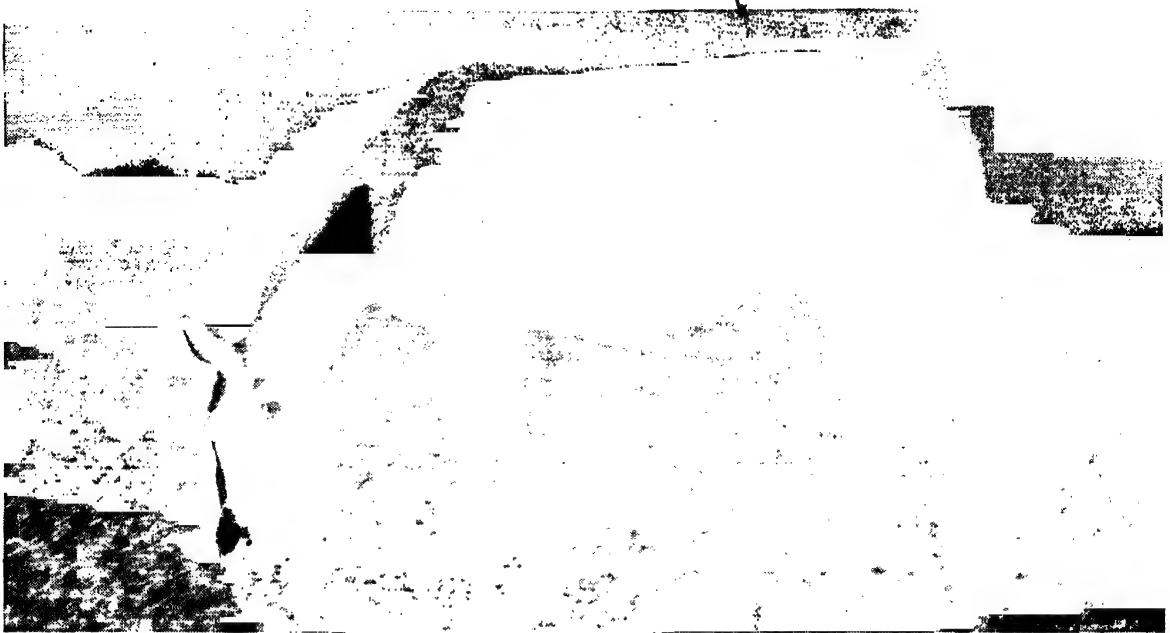
Here then are three distinct groups of beasts linking man and the familiar vertebrates with the "soft-bodied creatures." No doubt many more such links have existed on the earth, but for obvious reasons there is no tracing them as fossil remains.

Let us glance at one or two more "links" in the chain of life which have been a source of much puzzlement and heated controversy amongst naturalists in the past.

ONCE OWNED THE SEVEN SEAS

In the deep firths of Scotland, and on the fishing grounds north of the Shetlands, the trawl often brings up hundreds of what most people would describe as "some sort of shell-fish." But whereas a "two-piece" shellfish, like an oyster or mussel, anchors itself by one shell, or a bunch of threads pushed out from between its two shells, the lampshells, as these spurious shellfish are called, anchor themselves by means of a cord threaded through a hole in one shell only.

Some naturalists argued that these creatures were molluscs, like the snail and oyster, others that they were akin to the seaweed-like moss-animals one can pick up on every beach. Today they are usually placed in a special group, midway between the spiny-skinned sea urchins and the shelled animals or molluscs that have



ONLY LIVING WILD HORSE

MONDIALK

The Mongolian wild horse, otherwise known as Prejvalsky's horse after the man who introduced it to science in 1879, was once thought to represent the ancestor of all domesticated breeds, but this now appears unlikely.

now largely usurped their place in the scheme of things. But once the lampshells owned the seven seas, when the oyster and its kin were only in the making.

Most people think they know a worm from a centipede, or a lobster, or a butterfly's caterpillar; but confronted with the animal known as *Peripatus*, they might reasonably be afflicted with doubt. That indeed was the attitude of zoologists for many years after its first discovery. *Peripatus* is a soft-bodied creature common in many hot countries. It is a few inches long, has a beautiful velvety sheen, and with its many pairs of legs ambles along sedately like a caterpillar. When annoyed it shoots out long white threads of a milky appearance and extremely sticky nature.

REGARDED AS A GRUB

For a long time this strange animal was just a "grub," until about sixty years ago a member of the famous *Challenger* expedition made a study of it. Both its internal economy and mode of reproduction proved that it was a link between the higher worms and that legion of jointed animals represented by the pill bug, lobster and butterfly.

A particularly interesting link connecting the great extinct sea scorpions with more recent animals is the so-called king crab, or horseshoe

crab, common in shallow tropic waters on both sides of the Atlantic. It has been likened to a small boy crawling beneath a zinc bath and trailing a broomstick behind him.

GROTESQUE "LIVING FOSSIL"

Although this grotesque "living fossil" may measure a foot across, and twice as long, it has scarcely an eggcupful of meat in it. Even when it is young and its shell relatively soft, only the largest skates and rays appeared until recently to have any use for it. Now comes news that an enterprising syndicate has found a way to make something of the king crabs in Delaware Bay and has there almost exterminated them by turning them into pig food and fertilizer. Nevertheless this species of crab seems destined to remind the world for long to come of that remote past when life moved only in the shallows of the great waters.

The links enumerated, though vital in explaining the intimate associations between groups of animals at first sight very dissimilar, are admittedly of little immediate importance to man. Therein lies part of the explanation of their survival. They have as yet been of no economic value, but neither have they offered any resistance to man's progress, and so have been left to go their ways in peace. Further, most of these links are creatures of small size,



JAMES HORNELL (MONDIALE)

CONSERVATIVE ORGANISMS

Lampshells have existed in the same form for hundreds of millions of years. The cord by which they anchor is threaded through one shell only.

and unobtrusive, furtive habits, for which reasons they escape the notice of the foes to which so many other creatures succumb. They hide beneath stones, burrow in mud, plunge down into the abyss, and otherwise evade the attentions of a curious and ever-hungry world.

EVIDENCE FROM THE UNBORN

Every living animal is a link between the next-of-kin immediately above and below it. This is often more clearly evidenced in the living but unborn or unhatched embryo than in the fully developed creature. Within the parent or the egg-shell it hints not merely at its great-grandparenthood but its remote ancestry, and when we examine a number of embryos of widely different species we find that they have much in common, pointing to an origin from some generalized stock.

FAMILY LIKENESS

Broadly speaking, that toilsome road from crude beginnings to perfect man, dog or sparrow, is traversed again within the ovary. Von Baer, one of the great embryologists of a century ago, confessed that having preserved a number of embryos, but omitting to label them, he was later quite unable to say which were those of mammals, birds, reptiles, or fishes, so great was the general family likeness. This family likeness holds good throughout the animal kingdom. The "unborn lives," that is, the embryonic existences, of all vertebrates can be traced back to a gilled stage, proving clearly that the air-breathing creatures dominating



DORRIN LEIGH

LAST REPRESENTATIVE OF AN ANCIENT RACE

The fantastic king, or horseshoe, crab, whose ancestors flourished before birds flew, is not a crab at all. It is more nearly akin to the scorpions. It has thirteen pairs of limbs and unique book-like breathing organs.

EVOLUTION AS THE CLOCK TICKS



SIMILARITY SHOWN BY YOUNG OF DIFFERENT MEMBERS OF THE SAME GROUP
This close similarity indicates their common ancestry. The bulldog pup, for instance, has a fairly large nose at birth. Top rows: Shore crab, marked crab, edible crab, spider crab. Middle rows: Herring, sand eel, plaice, angler fish. Bottom rows: Bloodhound, cocker spaniel, Scottie, St. Bernard, bulldog.

the world today had their beginnings in aquatic forms.

Even when at last the human infant sees the light, it still bears sufficient traces of its more recent ancestry. Mr. Jones has more in common with the so-called "monkey man" when born than he has in later life. How truly a baby animal is its own great-great ancestor is apparent in many familiar beasts around us.

BABIES AND THEIR ANCESTORS

All dogs, with the exception of extreme forms such as the bulldog, show a remarkable degree of resemblance when first born; the still blind greyhound, dane, poodle, and Scottie pups give little hint as to the widely divergent roads that they will shortly take. Even the bulldog has a relatively generous allowance of nose at birth, proving a canine ancestry, however deftly art may later force him to suggest a toad.

Baby animals are of absorbing interest in the hints they give of ancestors of which the only portraits are colourless fossil remains. To take but one instance, zoologists insist that the lion,

now a creature of the open plains, was once a forest dweller, and has taken to its present mode of life by stark necessity rather than choice. No cat voluntarily stalks abroad for all to view beneath the midday sun.

FROM FOREST TO PLAIN

The lion of remote times probably lurked in deep forests, as the leopard still does, and was similarly coloured. So also may have been the vegetable feeders on which it preyed. But with the fear of death ever behind them, these latter sought safety in the open—and the lion followed. Spots were of little use in the new environment, and so gradually they gave place to that self-coloration typical of the lion today. The lion still wears his spots, however, whilst in the nursery. All lion cubs are spotted, and some zoo-grown specimens have been scarcely distinguishable from leopard cubs, which retain their spots throughout life.

Scientific artists such as Livingstone Bull, Charles Knight, Horsfall and others who specialize in reconstructing creatures of the past, usually represent the now extinct giant



WIDF WORLD

ZEBRA PREY OF THE KING OF BEASTS

The lion now prowls about open plains but his ancestors were denizens of the forest, like the present-day leopard. This we know from the fact that lion cubs are spotted, a coloration suitable for forest dwellings.



FALLOW DEER DISCARDS ITS SPOTS IN WINTER

Most deer have spots at birth but lose them when they are mature. The fallow deer wears its spots during all the summers of its life, discarding them only in the winter when they are no longer valuable.

hogs and many deer, etc., as striped or spotted. The view is justifiable, since most wild pigs, tapirs, and deer come into the world wearing jazz-patterned nursery suits which, like those of the lion, disappear with maturity. There are exceptions. The Indian axis deer and the fallow deer, both largely woodland dwellers, keep their spotted coats, and so "fade into the landscape," as did the leopard in the *Just-So Stories*.

GENEALOGY OF ANIMALS

There are ingenious and painstaking individuals who undertake to build up an imposing ancestral tree for the least distinguished commoner. The genealogy of animals goes back to remote times and is highly involved. The records of the rocks, of embryology, and many other factors must be considered. Tracing a mammal's immediate ancestors is relatively a matter of yesterday; tracking down the common origin of mammals and birds is a harder task. That both owe their being to a reptilian stock

is now well established, and an immense amount of cumulative evidence is provided to support this belief. Not a hundredth part of this evidence can here be cited, but one or two of the more interesting items may be given.

BIRD'S KINSHIP WITH THE REPTILE

The bird's kinship with the reptile is largely established by the study of skeletons, and particularly that portion of the bird's bony framework termed the "parson's nose." The end bone of this shows clearly in adults, and still more so in embryos, that it is really five bones welded together—a reptilian tail telescoped, so to speak. The "knuckle" of modern birds suggests little of a reptile hand in its adult form, but in the embryo there is often a close similarity, and the chick of the Brazilian hoatzin can actually scramble about tree branches on all fours, using very serviceable clawed fingers on its wing "knuckles" to augment beak and feet.

Many fossil birds possess typical reptilian teeth. The reptilian origin of birds is fairly clinched by the half-way bird *archeopteryx*, only two skeletons of which are known. This creature, which lived some one hundred and fifty million years ago, blended bird and reptile in a remarkable way, for it had a jointed tail like a lizard, teeth—which no living birds possess—wing-fingers and indisputable feathers.

"ONLY JUST" MAMMALS

In like manner the mammals' claim to reptilian ancestors can be established, and the more convincingly perhaps since two mammalian counterparts of *archeopteryx* are still to be found living in Australia. The duck-mole and the porcupine ant eater are "only just" mammals. They have hair, warm—or fairly warm—blood, and suckle their young. But they also have very reptilian skeletons, very reptilian—or bird-like—brains, and in common with birds and the majority of reptiles they lay eggs.

Fishes can similarly be traced to a common ancestry, although the checking up of each successive stage in a fish's past offers special difficulties. One cannot follow a fish at will in the water as one can a bird or beast on land, and the comparatively flimsy nature of most fish has resulted in their fossil remains being disappointingly scanty and seldom complete. Yet enough is known to be certain that early fish evolved from much more primitive creatures, like crustaceans perhaps, that they had no true mouths but only sucktorial discs similar to the lampreys, and that they had only gristly skeletons that developed into bone much later in the history of the group.

Fish, like dogs, poultry and other creatures, have a marked sameness about them when very

young. Unless such an infant fish can be reared to something like maturity in an aquarium, often a hard task, it is impossible to identify on sight the parentage of a "toddler" picked up in the trawl or tow net.

Strange as it may seem, the baby stages of the numerous fish that live in the seas which surround Great Britain and Ireland are tolerably well known, but those of the fresh-water fish of the British Isles either await discovery or, save for a few species, are at best debatable. Tracing these early stages constitutes an important part of the work done at the Fresh Water Research Station on Lake Windermere, the first institution of its kind in England.

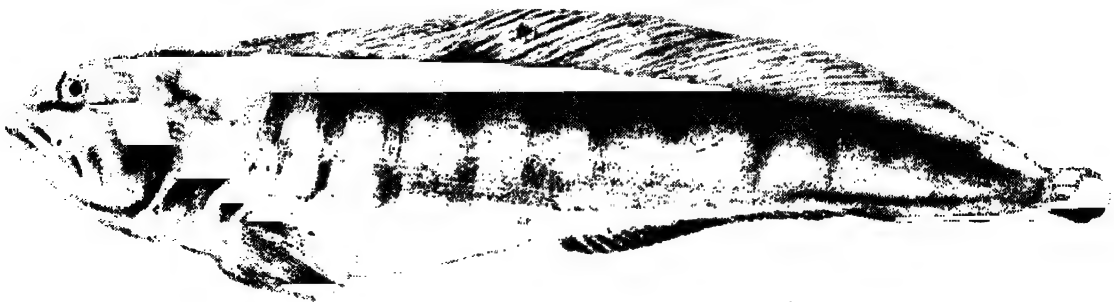
One often hears the remark that animals are perfectly fitted to their environment, in short that all animals find themselves in the best of all possible worlds for their purposes.

This is a lazy way of explaining things, and is also untrue. Animals, like ourselves, find themselves where they happen to be by reason of a variety of causes, and either make the best of things or go under. Environment plays an enormous part in the evolution of creatures of every kind.

WHEN CONTINENTS JOINED

A glance at the three maps on p. 2 will show how greatly the contours of the world's land masses have changed in ninety million years—quite recently as the earth's history goes. The more heavily outlined land masses are the more fertile ones, and it will be obvious that the period has seen not only great changes in the amount of land above watermark, but drastic alterations in climate.

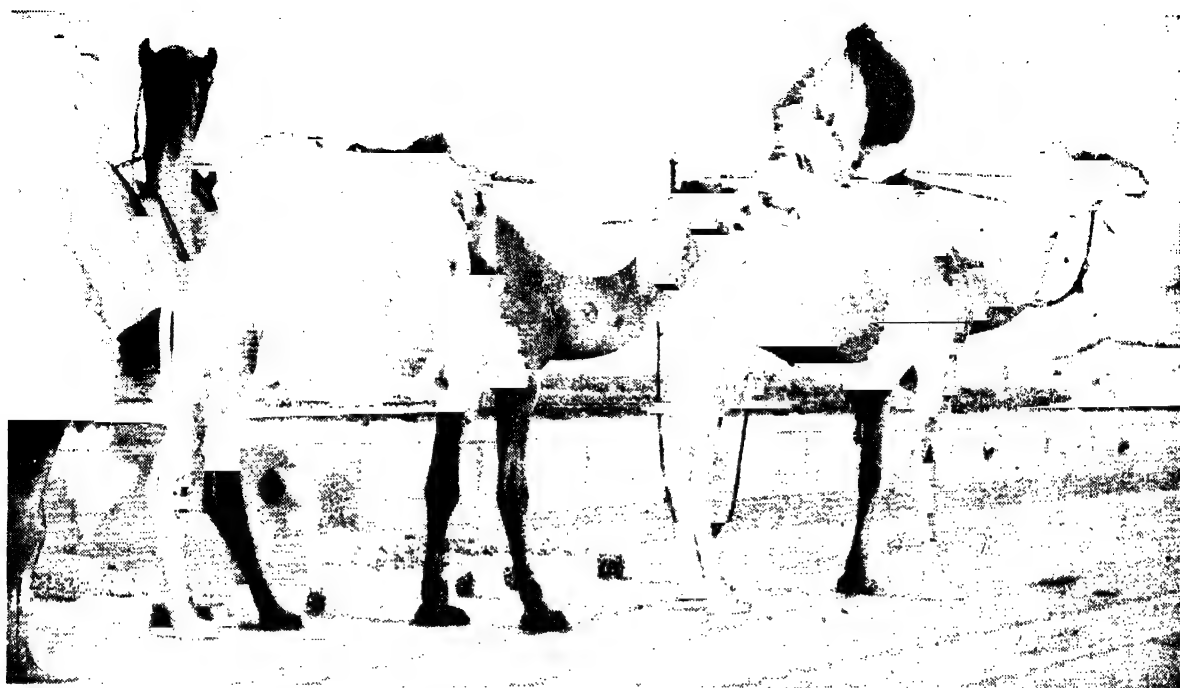
It was whilst America and Europe, Asia and Australasia were linked up by land bridges, that the roving herds and flocks gravitated to



ONE OF THE SILUROIDS

H. STOKES (MON)

The bodies of catfish are never ordinarily scaled, being either armoured with bony plates or else naked. They represent a great advance on the early fish whose skeletons even were not of bone, but of a gristly material.



AMONG THE OLDEST DOMESTIC ANIMALS

The dromedary, or Arabian camel, is not known in the wild state, unlike the Bactrian (two-humped) species, which is found wild in Eastern Turkestan. Even after many centuries of domestication the dromedary remains as agile and stupid.

what has proved were to be their final homes—or at least their homes to date, for the world still changes. Thus each of the great land masses has its characteristic animals.

THE FIGHT FOR LIFE

There came a time when Nature pulled up the drawbridge, so to speak, and there was no returning whence they came. But many of these creatures might do extremely well in another country, provided it offered a not too different climate, sufficient of the right food, and no new enemies with which the transplanted beasts might be unable to cope. How well some animals may do when transplanted we now know to our cost. The camel has proved most useful in Australia, but the rabbit has become a curse, and dogs and pigs introduced by man are in many places destroying native animals.

Let us leave human agency in determining an animal's environment out of the question for the moment, since it is dealt with at some length in another section. On the great continents competition in the fight for life was keen, and so the animals launched out in a variety of directions, each kind giving rise to numerous varieties or species, each adapting

itself to whatever territory it annexed. One striking example of how a given "strain" developed to its utmost capacity may be cited in the marsupials or pouch-bearing animals.

These creatures rank amongst the most primitive of mammals, next to the reptile-like duckbill and echidna. When mammals were first coming into their own, the pouch-bearers must have been in their hey-day, and spread over much of the warmer parts of the earth. Now an animal that must spend its infancy in a pouch is at a great disadvantage compared with creatures that are nursed outside their parents. As this latter type of animal became dominant, the remaining marsupials went under. Their small brains could not cope with those of the quick-witted milk drinkers who were nursed in nests and caves, and early taught to work for their own livings.

MAROONED IN AUSTRALIA

Very soon, that is to say in the course of a few million years, some of the pouch-bearers were making a last stand upon the mainland—in America. Others, seeking refuge far eastward, were isolated from their more intelligent competitors by the encroaching sea, and found themselves marooned on what we now call



RELATED TO DUCK-BILL PLATYPUS

The echidna, or spiny ant eater, is, like its famous cousin, a burrowing, egg-laying mammal, but does not swim. Its home is Australasia.

Australia. The American marsupials, unable to hold their own against the growing tribes of bears, racoons and monkeys, dwindled till we find them today represented by a few small species, leading a hole-and-corner existence; the tree-dwelling opossums owe their continued existence to their small size and nimbleness in escaping foes.

RIOT OF EVOLUTION

In Australia the small-brained pouch-bearers had things all their own way and, feeble folk though they were, embarked on a riot of evolution. In the course of ages they evolved on so many different lines that they mimicked practically all the better known mammalian types of the Asiatic mainland.

Kangaroos took the place of the big grass-eating camels, deer and oxen; little kangaroo-rats imitated the dainty antelopes. Other species, such as wombats, developed on the lines of terrestrial bears, and the more arboreal bears were portrayed in the tree-climbing koala, the "teddy bear" of our nurseries. There were imitation wolves and leopards, mice and rats, monkeys and ant eaters, but they all had pouches, and pouches they have to this day.

POUCHED BEARS AND LIONS

There were for many thousands of years pouched bears and pouched lions, but for reasons which still remain unknown they fell in the race, and today the herbivorous kangaroos are the largest pouch-bearers alive—living only so long as we let them.

The so-called "bears" and "lions" of Australia—to give them their popular titles—often exceeded the largest kangaroos in sheer body bulk, though not in span of limb. Their demise—unless through human agency—is a

mystery. Probably they fell, as did the sabre-toothed tiger in England, to the crude weapons but nimble wits of early man.

What happens on most islands applies also to the watery world. Large isolated bodies of water, lakes and inland seas have their own peculiar fauna. The inhabitants of the open sea are more generalized. Many are cosmopolitan, or if restricted to certain areas, differ little from local species some thousands of miles distant, provided conditions of life are similar. Thus many of the crabs found off the coast of England are almost identical with allied species in Japan. Similarly the denizens of the ocean abysses show a remarkable uniformity in design.

There is an extraordinary parallel to the pouch-bearers of Australia in the sand-hoppers



LARGEST LIVING POUCH-BEARER

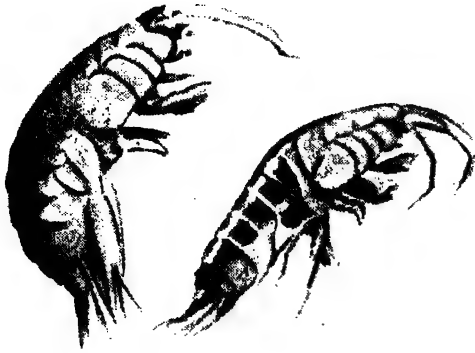
The kangaroo, largest living marsupial, or pouch-bearer, is a magnificent jumper. He lives in Australia, continent of marsupials.



WIDE WORLD

THE ORIGINAL TEDDY-BEAR

The koala is found in the south-eastern parts of Australia, where it is popularly known as the native bear or the native sloth. A marsupial, it belongs to the same family as the wombats. It is about two feet long and lives on a vegetarian diet, mainly consisting of the leaf-tips of the eucalyptus or gum tree.



SAND-HOPPERS OR BEACH FLEAS

Members of the amphipod order, they are found in every part of the world. In Lake Baikal they have launched out in widely-divergent directions.

of Lake Baikal in Siberia, the deepest isolated body of fresh water in the world. The sand-hopper, or beach flea, that gets into English luncheon baskets and swarms beneath the drift weed left by the tide is much the same kind of creature the world over, save in the Siberian lake. There it has launched out in scores of widely-divergent directions, and rings every change on sea life, from the glassy, free-swimming jelly-fish, to the lumbering crabs and lobsters far below.

SEX THE DRIVING FORCE

In another section of this book it has been shown how all living forms are the result of cellular multiplication, the piling of cell upon cell, and the gradual modification of those cells into groups, each performing some special action—feeding, warning off enemies, reproduction and so on.

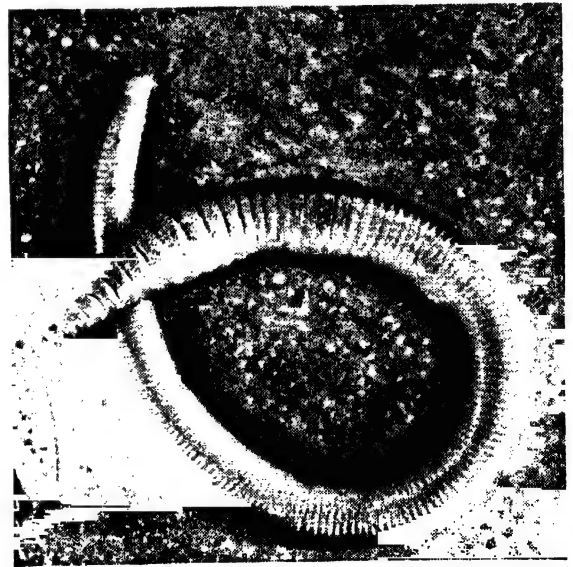
It is quite possible for certain plants and animals to multiply without the aid of another individual. But such production is like that of a convict condemned to perform the same

mechanical tasks year in year out—it leads nowhere. The bulk of living forms depend for their multiplicity upon sex.

Sex is the driving force, the internal combustion engine of the world. Mr. Aldous Huxley in his *Brave New World* paints an interesting picture of synthetic humans, creatures grown in test tubes according to patterns laid down by the State. One can only wonder how long such a State would continue. It is only the constant pursuit, the adventure brought about by sex that gives variety, change, without which there can be no real progress. The idea of synthetic humanity is not original. It is borrowed from the insects, and if put into practice would probably end in the insects' mechanical and unreasoning kind of life.

REPRODUCTION WITHOUT SEX

In a very large number of the lower animals reproduction is quite independent of sex. If one takes a little flat worm, such as crawls in abundance about the weeds of any pond, and cuts it in half, the worm suffers no inconvenience or pain. In a short time the head half grows a new tail, and the tail half a new head. Cut the worm down the central line, and each half soon makes up its missing portion, and life goes forward as before. Cut anywhere without detaching a piece, and the exposed surfaces by cellular multiplication begin to



HAROLD HASTIN

COMMON EARTHWORM

The earthworm will survive considerable mutilation. Thus either the head or the tail will grow again if severed cleanly.



SPONGE IN LIFE AND IN DEATH

On the right is a live sponge; on the left one that has been killed and cleaned. This animal is unique in that bits cut from it and planted out will grow without difficulty.

sprout new individuals, so that a very strange monster with several heads and tails presents itself.

Some of the more primitive worms multiply by literally bisecting themselves. There comes a time when the worm appears to be trying to walk two ways at once. It breaks in the centre, and each half becomes a complete worm adventuring on its own.

The same sort of thing can be seen happening in certain sea anemones, or in the only fresh-water anemone found in Great Britain—the hydra. This little creature, hated by fish breeders and aquarists for the toll it takes of young fry, simply cannot be destroyed by mutilation. Perhaps the mythical monster after which it is named was first conceived by some imaginative man of ancient Greece who observed how many simple animals renewed themselves when apparently destroyed.

MULTIPLICATION BY MUTILATION

An instance of this multiplication by mutilation occurred on oyster beds some years before the World War. The starfish is the bane of the oyster farmer, for it eats his precious shellfish on the grand scale. When therefore the oyster dredge came up, as it often did, crammed with starfish, the disgusted fishermen simply tore the animals in halves and flung the

pieces overboard. But the starfish came back. It came back twice over, for each half renewed itself, and the oysters paid the price of the farmer's ignorance. Today starfish are taken ashore and used as a fertilizer.

In late years it has been found possible to fertilize artificially—i.e., fertilize at second hand—salmon eggs, cods' eggs, and even dogs and horses, but so far the only creature which commerce has made to increase by mutilation is the bath sponge. You can plant out clippings of the sponge—which is undoubtedly an animal—and they will flourish like clippings of rose, geranium and many other plants.

CANNOT GROW LOST ORGANS

The power to regenerate lost parts seems to decrease as we ascend in the scale of life. One of the marvels of our age is plastic surgery. It can turn an old person into the likeness of a young one, for a short time help a criminal to escape justice by altering his features, or convert a man whom the instruments of war have made hideous into the fair semblance of a normal human being. But though our various tissues have wonderful powers of renewal, we cannot grow again lost organs. A severed finger is gone for ever.

This holds true of all mammals and birds, and to a large extent of reptiles. A lizard can

certainly grow a new tail, but the "join" always shows. Injury which just stops short at complete severance of the tail results in a forked tail, a grotesque attachment of more hindrance than help to its owner. But in the amphibians, half-way between reptiles and fishes, whole limbs can be renewed, though here again injury without severance may lead to a five-limbed animal, a clumsy, handicapped monstrosity. Fish renew damaged fins in like manner. This plasticity of vertebrate flesh was often turned to unpleasant account by old-time showmen, as when the Zouaves produced their "rhinoceros rats" by grafting a piece of a rat's tail on to its rightful owner's nose.

Regeneration is seen at its best amongst invertebrates, even in such complex ones as



W. S. BERRIDGE (MONDIALE)

TO ATTRACT A MATE

The male fiddler crab develops one brightly-coloured claw half as big as itself. This grows again if severed.

the crab. If a crab loses its claws or legs, the stumps are cast off at special joints, and the animal goes about crippled until the time comes to change its shell. Then it presently reappears with a new set of limbs, though the regenerated ones are not normal until several changes of shell have taken place.

REGENERATION IN THE EGG

This curious habit has been turned to account on the coast of Portugal, where there abounds a kind of fiddler crab, the male of which grows one claw half as big as himself. The fisherman simply collects this claw for market, and the crab obligingly grows another, though of slightly inferior quality.

In some of the lower vertebrates, such as the frog, regeneration can take place even in the egg. It is possible by nearly or very gradually completely severing a frog's egg to produce either "Siamese twins" or two complete individuals.

Sex appears quite a long way down the animal scale, and becomes more and more insistent and essential as we ascend.

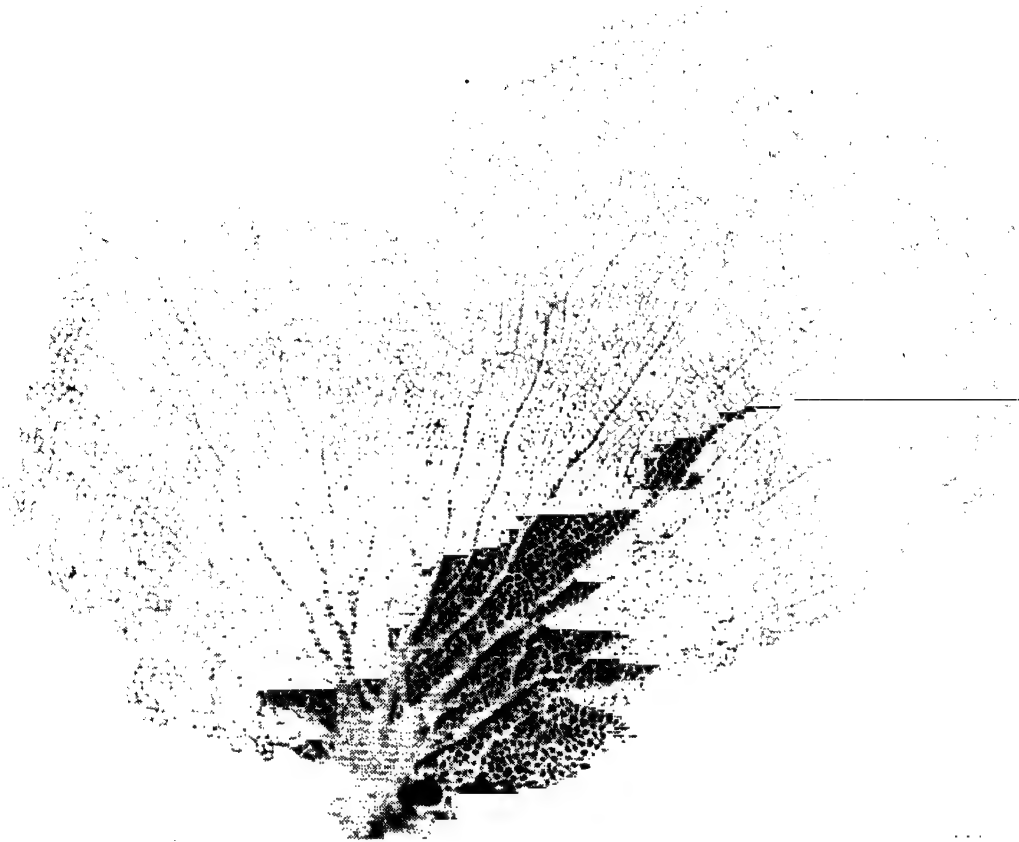
A great deal of attention has been paid of late years to sex proportions—or ratios—in all creatures, more particularly man and domestic animals. Darwin ascertained that the greyhound showed a greater disproportion of the sexes than any other animal, one hundred and ten males being born to every hundred females. Roughly, however, in vertebrates at least, the proportions tend to be almost equal. How far this is controllable only the future can show.

The offspring of the long-suffering frog have here, as elsewhere, suggested possibilities. Thus if a clump of frog spawn is hatched at a high temperature, or in acidulated water, more males than females result, and enforced retention of the eggs by the female produces an almost femaleless family. On the other hand frog spawn which is victimized by drought lets loose a swarm of female frogs on the world.

CASES OF SEX REVERSAL

Quite recently one or two very extraordinary cases of sex reversal (aided by surgical operation) in human beings have been made public. One can only wonder how such people fared in medieval times. In 1474, the councillors of Basle—who once tried a sow for murder—accused a cock of witchcraft, and had the wretched bird burnt in the market-place by the public executioner. The cock had laid an egg. Centuries later Professor F. A. A. Crew reported a buff-orpington hen which, after being a good layer and a good mother, wound up her career by growing spurs, crowing, and becoming an equally efficient father. Post-mortem revealed disease of the reproductive organs.

Low down in the scale of life sex reversal can be the normal, and vital to the continuance of the race. The Mexican swordtail fish is a popular pet of the home aquarist. There is often a marked outnumbering of males by females. As though to make up for this, a female after delivering her third family may become a male, the anal-fin becoming modified to form a pairing organ. Many molluscs habitually change sex, a familiar case being that of the oyster. As an adolescent it is a male, then it changes to female, and for the rest of its life lives alternately each succeeding year as male or female.



NATURE AS THE SUPREME ARTIST

HAROLD HASTIN

One of the gorgonias or sea-fans, beautiful corals which often grow to a width of three feet. In the course of one summer a sea-fan's offspring will develop to their full size and found new sprays of coral.

Usually, though not invariably, an animal's rate of increase is proportionate inversely to its complexity of mechanism. Many of the animalcula are only creatures of a day. A sponge clipping may swell to big proportions, and let loose a flood of eggs upon the waters within a few months. A plastic coral, such as a sea-fan, can lay its eggs, which will develop into jelly-fishes, and each jelly-fish settle down and found a new spray of coral between spring and autumn.

PUZZLES AND PARADOXES

A large number of insects pass through all the gamut of egg, crawling grub, dormant chrysalis, and pregnant parent in a few weeks. But as we ascend the scale there is a noticeable slowing down in the reproductive process, a slowing down often in direct proportion to the animal's size. The machine stays longer in the workshop.

The more the naturalist studies animals and their development, the greater becomes his

caution in laying down hard and fast rules. Puzzles and paradoxes arise at every turn to confound the new-born theory. Thus amongst fishes, the more primitive types, such as sharks and rays, apparently produce more "perfect" babies than do most highly-constituted types. Often the infant is delivered in an almost impregnable egg case, or it may be born alive. The infant sawfish—a blend of shark and ray—swims into the world with saw complete, the teeth wrapped in a tough covering to prevent injury to the parent's body wall when it makes its exit.

AT THE MERCY OF ALL

Most bony fish spend some time at the mercy of all and sundry before they themselves can become a menace. They enter life burdened with a yolk sac, and until this is absorbed have neither eyes nor appetites for live food. The baby troughs of a trout hatchery present a grotesque sight when full of fry, each infant fish skating about the tank floor on a big ball

of yolk, like a man trying to crawl on all fours with a cushion lashed to his chest.

Reptiles can almost without exception make a living at somebody else's expense immediately after being hatched. Not so the birds. Many, like the sparrow and robin, are helpless for weeks after hatching. In contrast the chicks of the ostrich are up and doing as soon as their baby clothes are dried. But this is partly a special adaptation to their exposed mode of life and a natural outcome of having rested longer within the egg. A sparrow can raise three or even four broods in a year, an ostrich only one.

Amongst the hairy milk-fed animals called



WIDE WORLD

MOTHER AND CHILD

Unlike most mammals, marsupials have no true after-birth, so the young come into the world in a very helpless condition. It is only an inch long.

mammals the advantages of leisurely manufacture are even more obvious. In the vast majority of mammals the unborn young one derives nutriment from its mother via the placenta, or after-birth, a spongy disc heavily charged with blood vessels. Thanks to this, the infant, however helpless it may appear, comes into the world in a very high state of development, and given favourable conditions soon asserts itself, in innumerable ways, as a creature far ahead of the average reptile or bird.

KANGAROO BABY AN INCH LONG

At a casual glance the marsupial, as represented say by the kangaroo, may seem quite "up to" the dog or ox. But if we could see a baby kangaroo born we should soon realize its inferiority to a dog. The nature of the phenomenon was a matter of the vaguest speculation until a naturalist at the Sydney Zoo actually saw a baby kangaroo make its debut. It was known that marsupials have no true after-birth, but not until the birth of a kangaroo was witnessed did scientists appreciate how undeveloped are these primitive mammals on their first appearance. The infant kangaroo, even in the big five-foot-tall "old man boomer" species, is at first only an inch long. In some kinds it is smaller. It is quite blind, naked, and with short hind legs.

INSIDE THE POUCH

The nature of the birth is as follows. The mother sits with her tail stretched out between her forelegs, and on to the tail rolls baby. Usually the maternal brain is of such poor quality that no effort is made to help the infant. One of two things may happen. It may fall off the tail and feebly creep away in the wrong direction, to be picked up by the first rat or crow. On the other hand it may be lucky, and, clinging to its mother's abdomen, painfully struggle on knees and elbows up through a forest of hair until it literally stumbles on the pouch. Once inside, it attaches itself to a nipple. The tip of the nipple swells like a bulb inside the baby's mouth, and there the infant stays attached, so far as we know, for months perhaps, until strong enough to venture into the open.

Still lower than the marsupials are those strange creatures the duckmole and the various porcupine ant eaters of Australasia. These are mammals, since they have mammæ, or teats, connected with milk glands, albeit the teats are



MARCUSWELL MCMWELL (LONDON)

SIZE AS A FACTOR OF BIRTH

The embryo elephant spends no less than twenty-two months within the parent, whereas a litter of lions or leopards can be produced in three or four months. The corresponding period for man is nine months.

of very crude design. The porcupine ant eaters lay leathery-shelled eggs, and then nurse the young kangaroo-fashion in a pouch. The duckmole also lays eggs, and when the young emerge feeds them not by means of true teats but by exuding milk over a considerable portion of its abdomen, which is porous and oozes the fluid food in an irregular and one would imagine rather wasteful manner. Mammalian babies such as these are scarcely on an equality with the calf that can stagger to its feet five minutes after birth.

MAMMALS IN THE MAKING

Size would seem to be a factor in determining the length of time a mammal spends in the making, though it will probably be long before we have anything like complete information regarding the various periods of gestation. We do not know precisely what period intervenes between the kangaroo's conception and introduction into the pouch; the gestation periods of the echidnas, armadillos, and ant eaters are equally enigmatic. Neither do we know very much of the pre-natal whale.

Of the more familiar beasts the elephant heads the list by spending twenty-two months

within the parent, which is seven months more than the giraffe, whilst ranging from eleven to thirteen months are the zebra, camel, llama, rhinoceros and sea lion. The dog, like the wolf, is "in pup" only about nine weeks. Possibly a cold climate slows down gestation, for the polar bear is not far behind the sea lion, with eight or nine months, whereas five months suffice for the more sheltered brown bear to produce its annual twins.

QUICK AND SLOW BREEDERS

The big cats are, for their size, quick breeders, twelve to sixteen weeks producing a litter of leopards, tigers or lions, which is only seven weeks longer than the domestic cat. Most of the monkeys and the big bats need six months, the majority of the man-like apes, as ourselves, are about nine months in the making, and so is the little red river hog.

Pigs are nearly related to the elephant, but the farmyard sow with her twice-yearly litters of a dozen piglets is no doubt a triumph—or victim—of that speeding-up which has overtaken most of our domestic animals. Wild pigs usually produce only three or four young at a time.

Most of the rodents are notoriously rapid

breeders. The porcupine, one of the largest, needs three and a half months to produce a family, a very elephant amongst the gnawing mammals. Compare it with the common rat. Many authorities have estimated its productivity, and though their figures vary, all are sufficiently horrifying.

A rat is sexually mature long before it is fully

An interesting example of this is offered by the common herring. A herring just under a foot long produces about forty-seven thousand eggs, as opposed to the six-foot-long ling which, as the most prolific of all animals, launches one hundred and sixty million young upon the world. It would be logical to expect the lings to far outnumber the herrings in the sea, yet the reverse is the case.

MULTITUDES STARVE TO DEATH

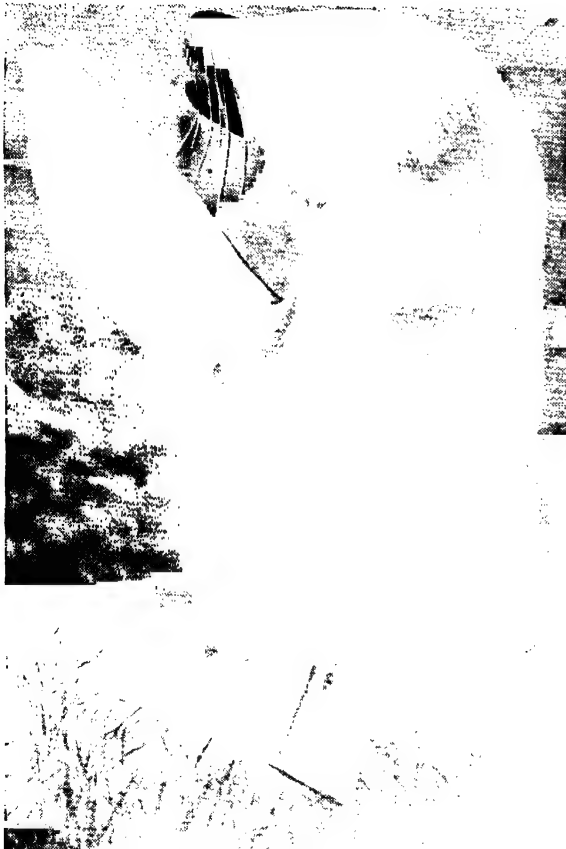
Both herring and ling are highly predacious fishes, and to live must from the first find prey smaller than themselves. For the herring this is an easy matter. The upper layers of the sea, to which the herring fry make their way, swarm with minute crustacea, and so the young fish prosper from the first. The ling, which inhabits lower levels, can find no such abundance of food, and long before game comes in sight, the bulk of the one hundred and sixty million have starved to death, or themselves provided meals for larger fishes, or jelly-fishes. So far as dominating the seas by force of numbers is concerned, neither herring nor ling is in the long run better off than the little shore blenny which carefully guards its few hundred eggs.

OYSTERS BY THE MILLION

Another example of how the output of animals is levelled up may be cited. The marine oyster ejects from one million to two million fry; four times as many as the equally abundant fresh water zebra mussel. The oyster spends most of its life cemented to a rock or shell. The zebra mussel spends the major part of its existence anchored by silken threads to a lock gate or water main. Both shellfish, however, commence life as free-swimming fry or larvæ. Why are not valuable oysters four times as abundant as the worthless zebra mussel?

The oyster fry, swimming hither and thither aimlessly by means of innumerable minute, restlessly lashing hairs, soon fall victims to all kinds of other animals. The mussel fry act with some circumspection. Each sinks to the river bed and waves aloft a single strand of silk. This attaches itself to the first passing fish. Eventually the baby mussel itself is thrown against one side of the fish and attaches itself by means of two sharp teeth, one on either valve of its shell.

Its presence causes the fish's skin to grow over it, and here the little mussel abides for some time, safely ensconced in a tough cyst. It may



FROM SEA TO LAND

The sea lion's gestation period is about three months longer than man's. It comes ashore to give birth.

grown, and can reproduce its kind when only four months old. A pair can produce in twelve months six litters averaging eight rats each. Calculate England's annual rat output starting with a capital of at least ten million couples. The annual additions to the population of mice must be equally impressive. Fortunately disease and other influences prevent these animals from annexing the country.

Animals, apart from limitations imposed upon them by size, also regulate their families largely according to the available food supply.

stay thus for three months, at the end of which time the cyst bursts, and the young mussel, now much changed in form, sinks to the river bed and becomes anchored for life. Its vulnerable stage has been passed in relative security.

Often a family cancels itself out in the course of nature long before outside forces offer it violence. The big spongy masses of egg

mice and young birds to feed her first-born. This, in bad weather amid mountain crags, may mean a long fast for the baby buzzard, and it sometimes breaks it by eating the next below. Thus it happens that families of three are common with buzzards living on the sheltered lowlands, but in Spartan climes are comparatively infrequent. Similar cannibalism



CALLED THE CAMEL OF SOUTH AMERICA

The llama is a domesticated member of the guanaco family. It has been used as a beast of burden for many centuries in South America. Its period of gestation is about the same as the sea lion's.

capsules laid by the whelk litter every beach after a storm. Some hundreds of capsules may go to each of these round honey-coloured balls, and in each capsule is about one hundred eggs. As soon as the first eggs hatch, the fry set to work on their unhatched cradle companions, so that at last a mere thimbleful issue, to be gobbled up by the nearest fish.

CANNIBALISM IN THE NEST

This self-massacre of the innocents is not confined to invertebrates. A parallel is offered by that highly constituted, intelligent bird of prey, the buzzard. Its eggs, like those of most birds of prey, are incubated as they are laid, one at a time, the first to hatch augmenting the mother's warmth to incubate its little unhatched brothers and sisters. It is a pretty picture of family co-operation.

But mother must often wander far afield for

can be seen in any village pond during the tadpole season.

The actual size to which any given kind of animal may attain is largely a matter of mechanics. The make-up, as much as food and environment, says "thus far and no farther." The principle can be demonstrated with a metal cylinder poised on four legs. If the legs are too slender they collapse. In a lifeless dummy the legs can, of course, be any girth, but this will not apply in a living mechanism.

BRAIN WEIGHS SEVENTEEN POUNDS

It is generally believed that the unwieldy proportions of some animals in the past did actually work their downfall. The elephant marks the limit to which legs may attain in thickness, and therefore weight of body. The lumbering amblypods, great hippopotamus-like



HAROLD EASTIN

GREAT HOUSE-BUILDER

The giant clam remains anchored in one spot all its life, devoting its energies to building a colossal home.

brutes that lived about sixty million years ago, piloted tons of body about with a brain of only a few ounces in command. Even the five-ton elephant with his seventeen-pound brain gets into difficulties at times but is seldom hopelessly

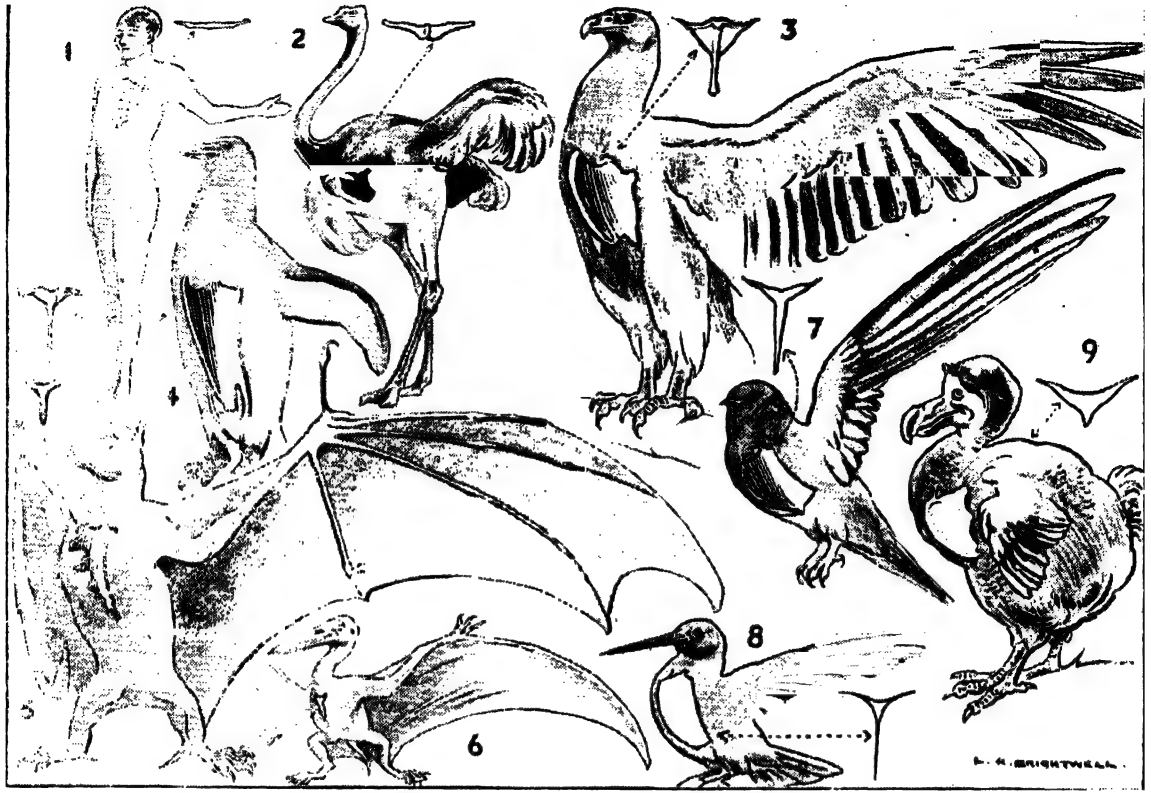
bogged, as the amblypods must frequently have been.

Lungs, a bony skeleton and a tough skin are amongst the essentials to generous growth in an animal, which is why all the largest creatures are mammals. Numerous factors have kept down the other groups. Insects breathe through small and complex tubes, and the largest insects have never exceeded a wing span of above two feet. The crustacea once reached in the giant sea-scorpions a length of nine feet, but here the constant necessity of casting the shell exhausted energy and so a size limit was reached.

Shelled molluscs must use an immense amount of energy in constantly adding to their cumbrous residences with successive layers of carbonate of lime. The biggest sea-snail has a shell two feet long, about half the length and not a tenth the weight of a giant clam's residence, but the giant clam remains anchored

**WINGS OF SERVICE ONLY WHEN UNDER WATER**

No wonder the two king penguins on the left are so critical of the chick, since the latter is of a different species, being the offspring of a black-footed penguin. It will soon lose its fluffy coat.



HOW THE KEELED BREASTBONE IS ESSENTIAL TO FLIGHT

Attached-on view of the breastbone of 1. Man. 2. Ostrich. 3. Eagle. 4. Penguin. 5. Bat. 6. Pterodactyl. 7. Swift. 8. Hummingbird. 9. Dodo. A man would require a breastbone projecting four feet to support the wing muscles necessary to raise his eleven stone.

to the sea bed for life, and so has more energy for house building.

With very few exceptions land mammals have proved winners in the race for size. They are beaten only by a few aquatic vertebrates.

GIANTS OF THE SEA

In the water weight is relatively of no account, and so a few groups of mammals, which it is believed changed from a terrestrial life to one afloat, left the landlubbers far behind, though at the expense of their legs.

Not even the much-sung dinosaurs, or baluchitherium, the seventeen-foot high extinct rhinoceros, could have outweighed the living sulphur-bottom whale that sometimes measures just one hundred feet from nose to tail flukes. Its nearest competitors are the forty-foot whale-shark and the giant squids of the Atlantic deeps, monster molluscs with a body length of only ten feet or so, the rest of them being just snaky tentacles.

Where the conquest of the air is concerned still greater limitations are imposed upon the

size obtainable. The ostrich, weighing perhaps 200 pounds, has no more power of flight than a man. The biggest flying bird is the condor with a weight of only forty pounds. Some of the giant flying reptiles had a wing span of twenty-five feet, more than twice that of a condor, and it is now being questioned whether they enjoyed anything like the condor's powers of sustained aviation.

IF MAN HAD WINGS

For a man to be able to fly it has been estimated that he would need a breast bone reaching to his knees and projecting four feet in front of him, in order to support the wing muscles necessary to raise his eleven stone. The heaviest bird for its size is the penguin. The king penguin, though standing at most only three feet high with neck outstretched, weighs from forty to sixty pounds. Its wings can only be put to practical use when it is deep under water, where its heavy bones give it stability and its vast jacket of fat buoyancy. The penguin's action under water corresponds

exactly to the flight of other birds in the air.

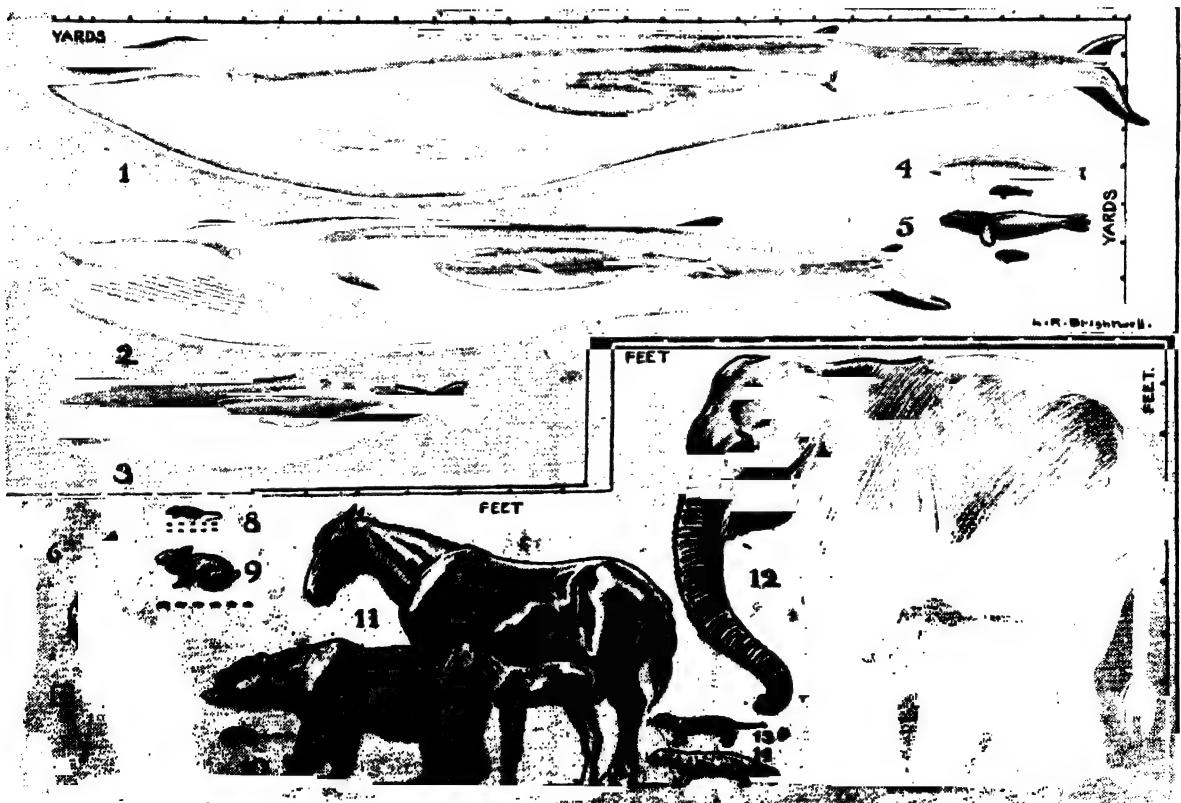
Looking back over the vistas of the geologic ages we see that every one of the great animal groups—as also the vegetable groups—has risen to a zenith and then declined. Just as primitive plants—mosses and ferns—once attained to the dignity of trees, so with the animals. Coral builders, starfishes and sea-urchins, insects, molluscs, fish—each has for a time dominated the world's stage. It is true that all these groups can still show giants of a kind. There are six-foot long sea anemones, starfishes a yard across, crabs covering eighteen square feet of ground, and squids as big as skiffs, but like other giants these are exceptions; they are no longer the standard of their class.

With the mammals, now the dominant form of animal life, a fair size is the standard rather than the isolated exception. It may be objected that large numbers of the great mammals have fallen by the way. Where are the giant elk of Ireland, the sabre-tooth tiger and the great cave bear, creatures that probably shared the

world with man less than a million years ago? The answer is that they have died out because their brains refused to march with the times.

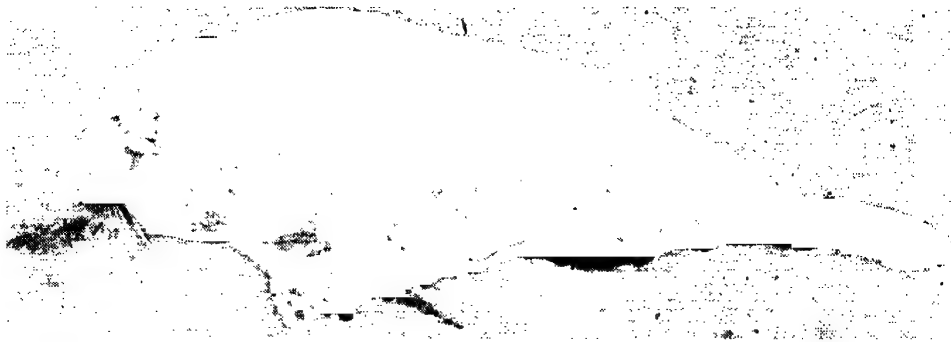
The moment the mammals appeared, growth became a matter not only of mechanics but of intelligence. To grow, an animal had also to be a colonist. When climates changed and food supplies dwindled, the dinosaurs collapsed but the mammals pushed on. When existing food supplies gave out, they roved in all directions looking for more, eating what they could *en route* until they found a land of plenty.

Modern man is not only a member of the highest class of mammals, the primates, he is the biggest animal in that class. He lacks the musculature of some man-like apes, but he tends to a greater average height than any of them. The gorilla can certainly throw a bigger chest and tip the beam occasionally at more than three times the weight of an average man, but will it always do so? We may be a long way from presenting a race of supermen, but we have some hopes of doing so: the gorilla none.



SIZES OF SOME OF THE MAMMALS AT BIRTH AND AS ADULTS

1. Blue or sulphur bottom whale. 2. Fin whale. 3. Sperm whale. 4. Porpoise. 5. Elephant seal. 6. Man. 7. Giant kangaroo. 8. Brown rat. 9. Rabbit. 10. Brown bear. 11. Horse. 12. Elephant. 13. Tiger. 14. Lion. Length and height are indicated.



LIVES ON LAND AND IN THE SEA

WIDE WORLD

The seal represents a mammalian mode of life half-way between that of the whales, which remain always in water, and those mammals that never enter it. Its feet are the main organs of aquatic propulsion.

THE ANIMAL KINGDOM

What is an animal? The question sounds simple enough, but one has only to overhear a group of ordinary people discussing a sea anemone to realize that the general conceptions of what constitutes an animal are far from clear. The dictionary does not entirely satisfy the average man's uncertainty. It tells us that the word is derived from the Latin, *anima*, breath; and that it means "a living creature possessing power of voluntary motion, as distinguished from, and contrasted with plant, on one hand, and from man, human being, on the other."

Modern scientists sum up the matter more lucidly when they state that an animal is a living organism dependent for its maintenance upon organic matter. Plants, it is true, depend very largely upon organic matter, and sometimes, as in the case of the pitcher plant and sundew, even upon living organisms. But they can also convert the air and sunlight directly to their needs in a way which no animal yet discovered can do.

Ever since the days of Ancient Greece, man has been persistent in his endeavour to "arrange" the world about him, to demonstrate the order which exists in apparent chaos. By the untiring labour of many generations of biologists, the plants and animals of the earth have been ranged in groups according to their affinities, and to each species a name has been given. The medium which science has adopted for its nomenclature is a strange blending of Greek and Latin which appears to the

non-scientific mind both cumbrous and difficult, but the use of the classical languages is a necessity if the same nomenclature is to be used and understood by scientists all over the world. A multiplication of nomenclatures would spell the direst confusion.

There are today over half a million recognized different kinds of animals in existence, and the list is being added to at the rate of over a hundred a year. Many have no popular names in any language, while such as have, frequently possess so many as to be a source of confusion even in the countries of their origin. In Great Britain alone the common stickleback is known by over a score of local appellations, and other countries in which it occurs have been equally generous. It is not surprising therefore that science has decreed the fish shall be recognized throughout the scientific world by one official cognomen, *Gasterosteus aculeatus*. The first title is known as the generic name—it tells us to what particular *genus* or group the fish belongs, whilst the second or specific name is that of the species or family. This marks the stickleback off from all other kinds of similar fishes included in the same group.

The whole system of scientific classification is based upon a complex process of working from the general to the particular, a gathering of all creatures into certain broad, main groups, and then dividing and sub-dividing upon a basis of increasingly minute distinction. It may be likened to the military arrangement of



MINUTE BUT MANY-CELLED

A rotifer, or wheel animalcule, feeding from a sea-moss spike. Minute in size, it is yet many-celled.

a fighting force into armies, an army into corps, divisions, battalions, companies, platoons and sections.

It will greatly facilitate our review of animal activities if the main groups of animals are clearly recognized. All living animals are divided into nine great armies, called variously sub-kingdoms or *phyla*—both terms signifying for ordinary purposes main groups.

Until fifty years ago naturalists were at great variance of opinion as to the true positions of many animals belonging to the more primitive

phyla, and even today one has only to hear general conversation to appreciate how vague are popular conceptions regarding the placing of such familiar forms as the jelly-fish, spider, and even the sea-lion. In any circus audience you are fairly certain to overhear a controversy as to whether the sea-lion is an animal (mammal), a fish, or a blend of both.

FIRST ANIMALS

In the lowest rank of the Legion of the Animals are placed those primitive creatures called the *Protozoa*—or first animals, and more popularly *Animalcula*. They swarm in the waters, both fresh and salt, and some even invade the soil. All are minute, and the simplest forms are little blobs of protoplasm with a central nucleus. A typical example, the *amœba*, teems both in soil and water, assuming all manner of shapes as it forces its way through whatever medium it happens to be in, and assimilating edible matter by literally “surrounding” it.

More complex forms build elaborate houses out of mineral substances suspended in water, which later go to form deep deposits on the sea floor, and eventually under compression, beds of solid rock. Others again are termed flagellates or whip bearers, since each has a minute hair-like attachment by which it literally whips itself through the water.

“HAIR WHIPS” OF THE SPONGES

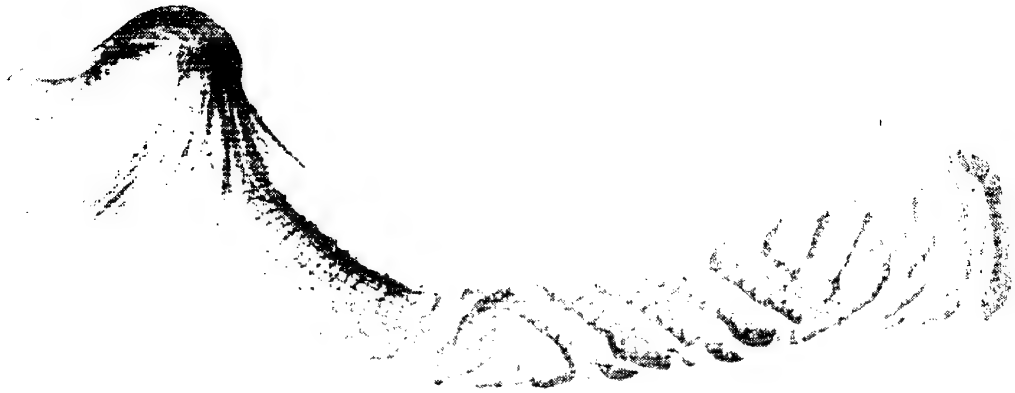
In the next group, the sponges (*Porifera*), we see this device of the whip amplified. It often takes the form of dense manes of violently agitated hairs, which form very efficient organs of propulsion. The familiar sponges have their interiors filled with “hair whips,” forcing water, and with it minute food particles, through the entire organism.



HAROLD BASTIN

HIGHER THAN THE AMŒBA

The slipper animalcule, or paramecium, is one of the largest of the single-celled animals called Protozoa. Size : one hundredth of an inch.



VENUS'S FLOWER-BASKET

HAROLD BASTIN

The flinty sponge Euplectella, one of the most beautiful of marine animals, lives in the mud on the floor of the sea, where the enormous pressure of water forces it to assume an extremely diffuse and ethereal form.

The second section, *Coelenterata*, or hollow-bodied animals, includes the corals and jelly-fish. Here we see the first beginnings of a stomach, for the entire animal is little more than a bag, into which food is passed by special organs—the feeders or “petals” of the anemones, the “streamers” of the jelly-fish.

The vast army of the worms (*Vermes*) brings us to another group presenting an infinite variety of forms, built on a cylindrical plan, and more complex than the foregoing in that there are separate orifices for the assimilation of food and the ejection of waste matter.

MOSS ANIMALS MIMIC CORALS

The moss animals (*Annelids*), typified by the sea-mat common on the beaches of the east coast of England, stand midway between the worms and the next legion, that of the spiny-skinned animals (*Echinoderms*), the starfishes, sea-urchins, etc. Although many of the moss animals mimic corals in their adult stages, their larval or immature forms are often easily mistaken for those of some worm. The precise relationships of these abundant animals are still matter for controversy, and the group is here placed in the general scheme only for the time being.

SKIN FORTIFIED WITH LIMY MATTER

Sea-urchins, starfishes and sea-cucumbers, though very unlike at first glance, have many points in common. All are built upon a pentagonal plan, and the skin is fortified with calcareous matter gathered from the surrounding water. Since only enough of this limy

housing material is available in salt water, all the species are marine. They have a most complex system of internal canals, which force water through innumerable hollow “tube



ANIMATED FOOD-BAG

HAROLD BASTIN

The jelly-fish is a member of the Ctenophora phylum, in which we see the beginnings of a stomach.



COVERED WITH STRANGE APPENDAGES

Sea-urchin and starfish. Upper surface of the latter and also of the former, showing spines, sheers, pincers and grapnels invisible to the naked eye but useful for feeding, cleaning and protection.

feet," enabling the animal to progress over rocks and other difficult objects.

A sea-urchin is literally a starfish "sewn up," that is with all the arms bent over till they touch, and cemented together at the edges. This is shown in the illustration, and also how the spiny-skinned animals in addition to their "water legs" are covered with strange appendages—spines, sheers, pincers and grapnels, invisible to our naked eyes but perpetually busy feeding, cleaning or protecting their owners.

The curious link group termed lampshells, or *Brachiopods*, mentioned in a previous section, stands midway between the great army of the starfishes and the *Mollusca*. The *Mollusca*

include such familiar forms as the oyster, mussel, whelk, snail, octopus and cuttle fishes.

The *phylum* of the jointed animals probably forms the greatest of all the several main groups, both numerically and as regards variety of species. It includes the crustaceans—water-fleas, barnacles, crabs, crayfish, lobsters—spiders, scorpions, mites, centipedes and insects. The last are recognizable from all the others in that when they arrive at the adult or perfect state they have three pairs of walking legs.

All members of the group are segmented, that is to say the body is divided into rings, each bearing a pair of appendages. Some of these may be reserved for walking purposes,



SEA URCHINS: STARFISHES SEWN-UP

HAROLD BASTIN

Members of the spiny-skinned Echinoderm group. They are all marine, have their skins fortified with limy material, and are built on a pentagonal plan. They climb over rocks by means of "tube-feet" through which water is forced.



OCTOPUS LYING IN WAIT FOR PREY

JAMES HORNELL (MONDIALE)

Of the Mollusca group, its cousins include cuttlefish, snails and mussels. The circular orifice (shown about an inch below the eye) is the termination of a tube through which water is expelled with great force, driving the creature along back first.

others modified to form wings, feeling organs or a number of complicated mouth parts. Terrestrial forms breathe by a system of tubes through which air is pumped; aquatic species respire by means of gills or air tubes.

"THE BRIDGE-THAT-WALKS"

Lastly we come to the great army of creatures having a central nerve chord. The *phylum Chordata* or *Vertebrata* embraces certain obscure "links" such as the sea squirt, and more importantly the fishes, amphibians—animals such as frogs and newts, that spend part of their lives in the water and part on land—reptiles, birds and the hair-covered, milk-fed creatures termed mammals.

It is this last group which naturally enlists our chief interests and sympathies. We have more fellow feeling with its various members than with the invertebrates, or backboneless animals, however great their scientific interest. The outstanding feature of the vertebrate is its vertebral column or backbone. On this has been founded the long series of adventures in land colonization which has culminated in man.

All vertebrates, however unlike in shape and

habits, are built upon the same general plan, which, like the main theme one hears in a musical composition, can be seen running through the entire series. The study of this main theme and its variations forms that most fascinating of the sciences, comparative anatomy, and it can at least be glanced at without involving any cumbrous technicalities.

The vertebral column or backbone has been very aptly called by Professor W. K. Gregory, of Columbia University, "the bridge-that-walks." It is a suspension bridge built on the same essential principles employed to span the Forth.

BEGINNINGS OF THE BRIDGE

The animal bridge had its beginnings in the primitive fishes that first developed paired fins. Some living fishes offer hints as to how the bridge was first brought ashore. We see the common angler fish—the "rock salmon" of commerce—and the common gurnard crawling or shuffling over the aquarium floor by means of their breast fins. Some tropic fish like the mud skipper and climbing perch can even shuffle out of the water and on to dry land, or even struggle up vertical surfaces.



HAROLD BASTIN

DEVIL-FISH

The common cuttlefish is one of the cephalopods, regarded as the most advanced invertebrate animals. They have well-ordered brains.

A number of fish thus survive long periods out of water, thanks to such devices as accessory breathing organs derived from specially modified swim bladders. Such first lungs made further progress in the early amphibians, the fish-reptile creatures that swarmed in the primeval forests now represented by our coal measures. These creatures, often of enormous size, are known to have made excursions ashore, but like our modern newts and frogs could never be independent of the water for long. Amphibians have soft spongy skins, and partly breathe through them.

This porous quality of the skin has always been a heavy handicap to amphibians in colonizing the land. Any excursion far from water involves the danger of literally drying

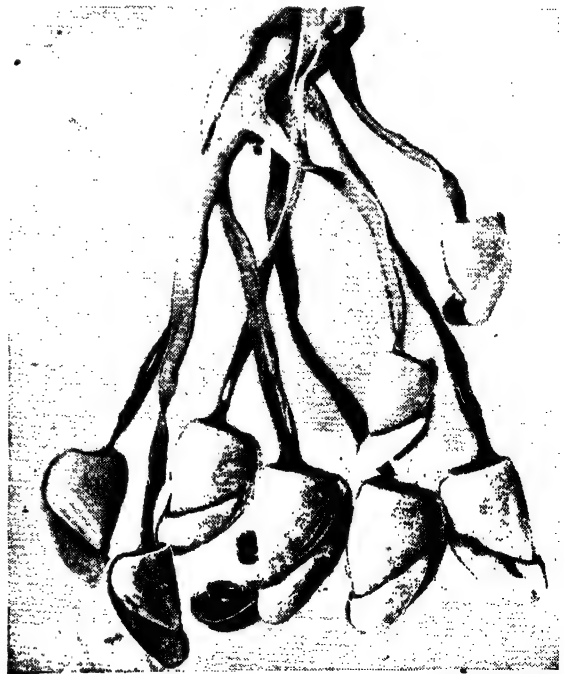
up. In March, when the toads are searching for a pond wherein to deposit their eggs, one can often find some that have fallen by the way. Here the sun has caught them and mummified them where they died.

PERFECTING OF THE LUNG

For breathing apparatus to work on dry land, it must be kept moist. Unless our lungs enjoy a certain amount of humidity, respiration is impossible. The precise stages by which certain amphibians developed hard heat-resisting skins, and lungs sufficiently capacious to sustain them for periods without other aid, are not entirely known, but once this transpired the conquest of the land was assured. The perfecting of the lung and the toughening of the skin literally set the vertebrate upon its feet.

PIONEERS OF MILLIONS OF YEARS AGO

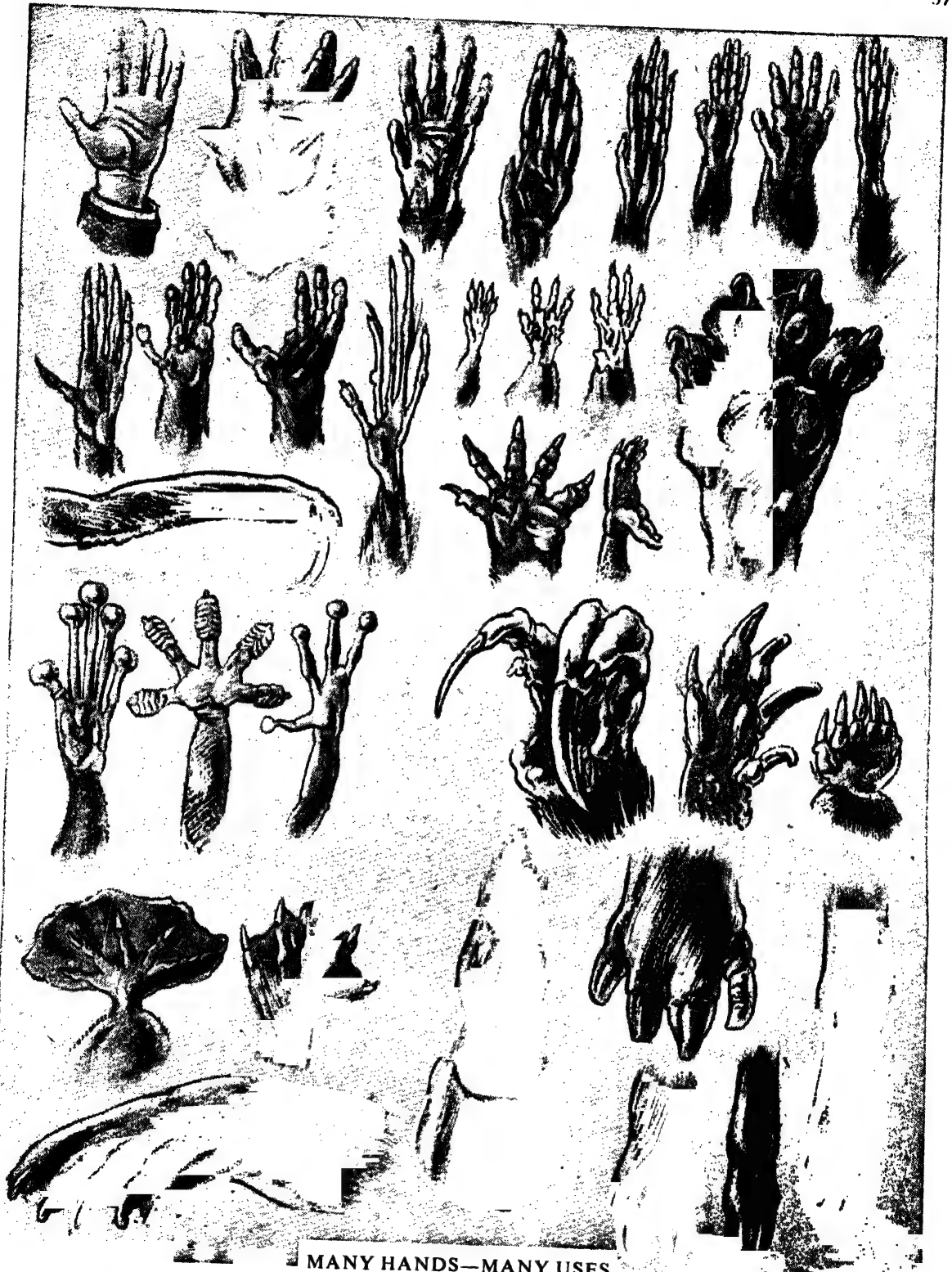
To the casual observer a newt and a short-legged lizard are much alike, but gently prod each of them, and the difference is demonstrated in striking fashion. The newt practically rows itself over the ground; its human-looking hands and well-formed limbs are little better than oars. The lizard raises its belly clear of the ground, and in a moment leaves the newt far behind. The bridge at last walks.



HAROLD BASTIN

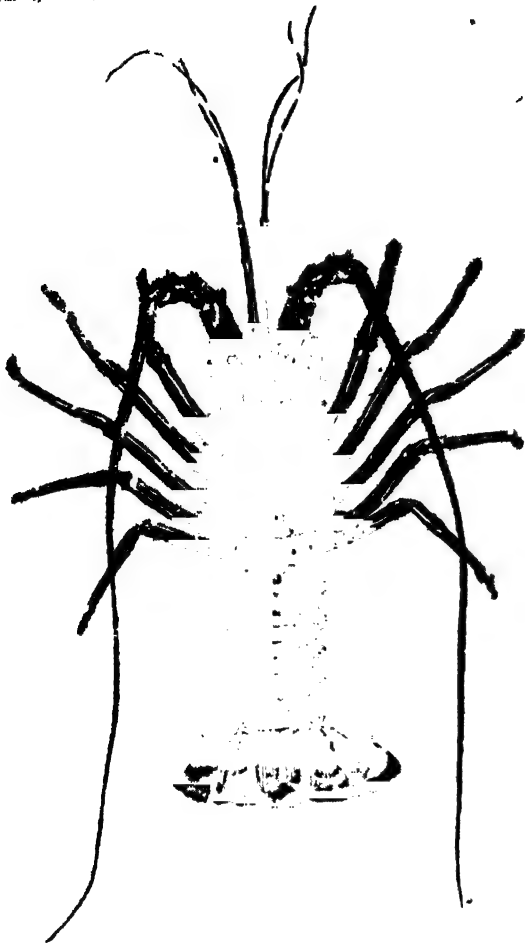
OF THE CRAB FAMILY

Barnacles belong to the phylum of jointed animals. The ancients thought that geese were bred from these organisms.



MANY HANDS—MANY USES

Holding hands : Man, gorilla, chimpanzee, orang-utan, gibbon, rhesus monkey, baboon, spider monkey, woolly monkey, lemur, patto, aye aye, shrew, rat, squirrel, sloth, kangaroo, chameleon, leopard. Sucker-pad hands : Tarsius lemur, gecko lizard, tree frog. Digging hands : Ant eater, armadillo, mole. Swimming hands : Duckbill, otter, seal. Running and walking hands : Horse, tapir pig, deer, hyena.



BURGER'S CRAYFISH

WIDE WORLD

Crayfishes are among the most highly developed of the crustaceans. This species is found along the South African coast.

When this was first achieved, about two hundred million years ago, the bold pioneers presented a certain sameness. Those early

terrestrial reptiles rather suggested a child's crude attempts at portraying a quadruped. The pioneer walking bridge had a shortish tail hung at one end, a rather shapeless head at the other, and was itself slung between two pairs of extremely undistinguished "generalized" legs.

FINGERS AND TOES

But life ashore offered enormous possibilities for exploration, it invited the adventurers to not merely waddle but to walk, run, dig, climb and fly. Astonishing variations were soon played upon the simple theme of the jointed limb, with its terminal digits—fingers and toes—which are really only modifications of the fin-rays seen in fish.

Every conceivable kind of limb was in course of time hung at either end of the bridge, according to its owner's needs. At a first glance there is admittedly very little in common between the forearm of a man, frog, deer, bear or sloth, the wing of the bat or bird, and the flipper of the whale. But reduce these all to the common denominator of dry bones, and their essential oneness or homology is at once apparent.

VANISHED THUMBS

The first exponents of the walking bridge had five fingers and five toes. These were useful enough for just paddling over the ground, but their scope was very limited. In course of time some animals found five toes too many. They made swift, sustained progression impossible, and so some were eliminated, as in the horse, deer, and pig.

Where the hind limbs only were used for progress, the fore limbs remained normal, as in the case of the kangaroo, which retains an ordinary hand, but has dispensed with one



BURROWERS

These animals are all unrelated, but they are, nevertheless, all built along the same general lines, because they all burrow in the same way. Basset hound (once used for badger-hunting), mole, cockchafer grub, mole cricket, burrowing prawn.



TEETH USED AS TOOLS

Differing vastly in many respects, for their other habits are very dissimilar, these animals yet have teeth of the same type, since they use them in the same way. Elephant, walrus, beaver, Chinese water deer.

hind toe altogether and is well on its way to converting two of the remaining toes into one.

Some animals, still keeping their bridge in a horizontal plane, took it aloft, and hauled it about, upside down, amongst the tree-tops. Here again wonderful modifications took place in the bridge's supporting columns. The orangutan turned four of its fingers into hooks, causing the fifth or thumb to dwindle from disuse. In some monkeys and other arboreal quadrupeds it vanished altogether. The sloths have wiped out two, or even three fingers and toes, much as the horse and deer have pushed some of their digits into the background, not by climbing but by persistently hammering hard earth.

HANDS AND FEET FOR DIGGING

When the hands and feet were used as digging instruments, again the e was at once lost and gain amongst the digits. This is suggested in the series of "digging" tools pictured. It will be noticed that whereas the hands are in some cases altered past recognition as hands, the

feet, being mainly used only as spades to fling aside the earth excavated by the fore limbs, have undergone comparatively slight divergence from the original theme.

One of the most fascinating features of comparative anatomy or animal make-up is the manner in which totally different animals, by leading similar ways of life, have developed the same parts of the body in the same fashion. Unlike in all other respects, they still have these features in common.

WALKING ON THE CEILING

No one could mistake the little monkey-like tarsier of Borneo for the tree frogs of the same region. But if only the hands and feet of these creatures were shown some confusion might be excusable. Tarsier and frog spend their days clinging for life to slippery bamboo stems, and like the gecko lizards that see the world by walking on the ceiling, have developed adhesive sucker discs whereby to conquer a "skating" surface. In the matter of flight, we shall find the same principle holding good, i.e., the hand

made to do the same work in similar ways by totally dissimilar animals.

The living bridge had its origin in the water and was dragged ashore. Some animals dragged it back into the water. It is now generally believed that the whales, and also the sea-cows and manatees, the largest aquatic mammals, are the descendants of land animals which, either in pursuit of food or to escape from foes ashore, put the clock back, so to speak, and reverted to the source of their origin, the great waters.

In these two very different groups of mammals the hand once more became a fin, but only superficially as regards its construction. Strip off the skin and fat, and below we find the familiar fingers—fingers that could no longer retain their grip on land. Another parallel line of development seen in whales and sea-cows is the loss of the hind limbs. When existent at all they remain only as vestiges.

DWINDLED BY DISUSE

The seal and sea-lion present a "half-way" state of reversion. They have reached the same goal, a life spent partly ashore and partly afloat, but by different roads. The seal has made its feet the chief organs of propulsion. Placing them sole to sole, it waggles them, as does the seaman his oar over the boat's stern, and so progresses in a lateral plane, like a fish. The sea-lion swims with its fore limbs, steers with

its hind, and is altogether a more handy beast.

The seal's arms and hands have dwindled by disuse almost to the point of impotence. It uses them ashore to scramble over rocks, but is at almost as great a disadvantage as a too fat man trying to perform a similar feat with his hands and feet manacled.

One animal alone successfully tilted its bridge on end. In the course of a million or more years man achieved this, partly as a result of special modifications of his pelvis, but chiefly by developing the lumbar curve or small of the back, thus enabling him to poise the centre of the body over the centre of support.

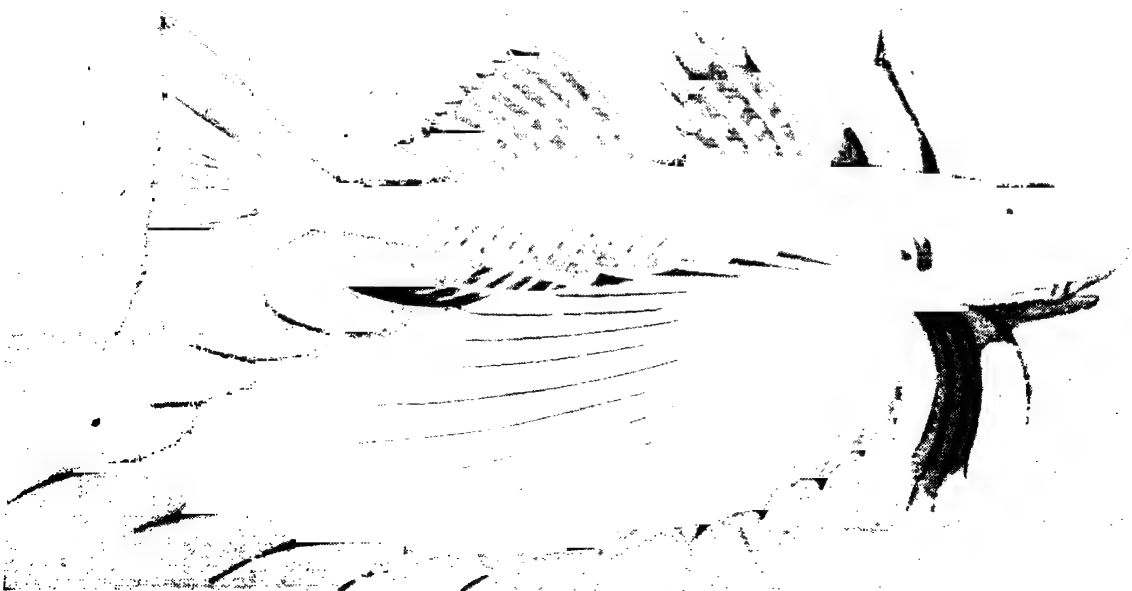
NECK AND TAIL AS BALANCERS

The apparent uprightness of such bipeds as birds, or semi-bipeds like kangaroos, merely mimics the human pose. The bird's long neck and the kangaroo's tail both serve as balancers, and the same applies to those nightmare creatures of the past, the bipedal dinosaurs.

The average bird has a much longer neck than meets the eye, as all who have plucked a chicken will have realized. Without this the bird would tumble backwards, and the kangaroo, shorn of its tail, would similarly pitch forward on to its nose.

We will now examine in more detail some external features common to vertebrates.

"Tail" is one of our many loosely used words. We speak of the lobster's tail and the



ONE OF THE CRAWLERS

The gurnard, like the angler fish, crawls along the bottom of the sea by means of breast-fins. Some tropical species, like the climbing perch and the mud skipper, can crawl on dry land and even up vertical surfaces.



CRANE PACIFIC EXPEDITION (WIDE WORLD)

BIRDS, REPTILES AND A MAMMAL

Seen on a lava ledge in Narborough Island, Galapagos Archipelago, five hundred miles west of Ecuador, in the Pacific, four cormorants, two gulls, five marine iguanas and a sea-lion. The cormorants' wings are too weak for flight.

tail-end of a wasp, but the tail is truly a vertebrate phenomenon. It is a piece of the vertebral column or bridge "left over," and originally helped to propel the adventurers on land ashore. The few terminal bones of the human spine, spoken of as the *os coccyx*, are a legacy from our remote ancestors the fishes. As one authority has aptly put it, "with our tails we swam to supremacy."

MANY USES OF THE TAIL

The tail was primarily an organ of propulsion. It is still largely the driving force of the twenty thousand species of fishes living today, although some have learnt to employ it as more than a simple organ of locomotion. The thresher shark uses it to round-up schools of fish, the conger-eel and sea-horse use it as a grapnel or anchor, the mud skipper and anabas employ it to heave themselves along when making a shore excursion. But most aquatic creatures, whether fishes, crocodiles or otters use their tails to force the water aside with a wagging motion, i.e., in a horizontal plane.

In all such animals the tail is compressed to form a blade with two edges, one above and one below, the former sometimes augmented by a crest. When the tail is compressed to form a horizontal blade, it is moved up and down and not from side to side, driving its owner forwards with a rocking motion.

This sort of tail is much less abundant than the wagging kind, but we can see it working with wonderful efficiency in the whales and

manatees, and to a lesser degree in the beaver. The beaver also uses its tail with a lateral and slightly screwing motion to serve the purpose of a rudder. Unique amongst tails, it can also function as an alarm gun by dealing the water surface a sounding smack when danger threatens.

When the tail was finally carried upon dry land a host of other jobs awaited it. The first pioneers, the lizards, swung it just as they had done in the water, and if an enemy stood in its way, so much the worse for the enemy. A big monitor lizard or a crocodile can knock a man off his feet with a single swing of the tail, and the African ant-bear when cornered can put its tail to a like purpose. In some extinct beasts, like the stegosaur and the giant armadillos that once ranged the pampas, the tail bore enormous spines that must have spelt destruction to anything in their path.

TAIL AS SHOOTING STOOL

In wild Nature the tail very frequently literally wagged the dog. Having rowed its owner ashore, it gave greater freedom to his fore limbs by helping him to raise them both together from the ground. When developed on sufficiently generous lines, the tail makes a good shooting stool. Many lizards past and present so use it, and it has served in this capacity for the extinct giant ground sloths and countless generations of kangaroos. In the latter it is powerful enough to take the animal's entire weight.

When two male kangaroos fight they heave themselves aloft upon their tails and meet heel to heel, each fencing with one free foot for the chance to lay bare his opponent's interior. The woolly monkey uses his tail as a stool in a different manner. Curling the tip into a circle, he plants this firmly on the ground, and then, making the rest of his tail rigid, leans back upon it in a luxurious fashion.

With the great majority of quadrupeds the tail serves largely as a fly whisk, and subconsciously it is an eloquent index to the owner's emotions of the moment. The "language" of a dog's tail needs no elaboration, neither does the cat's nor the cow's tail call for comment. When the tail is generously haired it may, as in the case of the squirrel and the ant eater, make a handy coverlet at bed-time, and the scaly ant eaters or pangolins use their tails as door stoppers, blocking the

entrances to their burrows against unwanted callers.

Yet another rôle played by the tail is that of a tribal badge, or follow-my-leader sign. This is usually its last use, the only employment that can be found for a tail too short or immobile to do more active work. The rabbit's "bob" is an example that will occur to all. More decorative amplifications of the idea are seen in the short dark tails of many deer and antelope, neat little appendages set in strikingly marked or coloured frames of horseshoe design.

When a vertebrate took to life in the trees, the overflow from its walking bridge entered on another phase of usefulness. The strictly arboreal vertebrate animals without tails can be almost counted on the fingers of one hand. The sloths are tailless, and so also is the Australian teddy bear or koala, but both are forced to cling tenaciously to any support



TREE CLIMBING UPSIDE DOWN

WIDE WORLD

The two-toed sloth, a native of tropical Central America, always climbs upside down. His movements are slow compared with those of most monkeys, because, unlike them, he has no tail to act as a balancer.



MEANS OF LOCOMOTION IN THE WATER

Left: two-oar swimmers, using paddles; boatman bug, swimming crab, frog, sea-hare, cormorant, sea-lion, penguin. Right: one-oar swimmers, using their tails as propellers; dolphin, seal, crocodile, fish, otter (swims dog-fashion, aided by tail).

offering, and both move in slow motion. So too does the orang-utan. It is dangerous to hurry a Blondin act without a balancing pole.

LIFE ON THE TREE TOPS

A balancing pole is indeed a tail's first function in tree-top life, and is essential to rapid movement. The only nimble arboreal mammal that dispenses with one is the gibbon, but it makes up the deficiency by spreading its abnormally long arms horizontally. All arboreal squirrels, monkeys and lizards have long tails, and in a review of these we meet every degree of development between the tail that is a balancing pole only and the tail that is much more—a fifth hand.

Only two lines of reptiles, the chameleons and the snakes, have developed hand-like tails, but amongst mammals the grapnel tail manifests itself in such diverse forms as those of the various South American monkeys and honey bear, the Himalayan catbear or binturong, the tamandua and little ant eaters, various porcupines, and a regiment of opossums.

The honey bear or kinkajou uses its tail with even more effect than the various monkeys who vie with it in raiding birds' nests and wild hives. The honey bear, dangling head downwards from a branch when committing one of its raids, stages a quick get-away from the irate owner by simply climbing its own tail, and so fading literally into the night. One monkey, the woolly monkey of Brazil, converts its tail into a hammock by hitching the tip over one branch, its toes over another, and then, leaning back against its caudal appendage, swings at ease a hundred feet above the ground.

GLANDS TO LUBRICATE PLUMAGE

The tail in most birds is no more than a support for feathers and the oil glands which serve to lubricate the plumage against the incursions of damp. To such uses has the lengthy appendage brought into the world by archeopteryx, the first bird, been converted. In many aquatic birds, such as ducks, divers and guillemots, the tail is a serviceable rudder, and in a few diverse species it even functions as a stool.

This is seen well in some penguins, who make a tripod of heels and tail, but more remarkable is its similar employment by the woodpeckers. These birds live, as do—in working hours—steeple-jacks, namely up a pole. The steeple-jack retains his stance in this perilous position by means of a strap round his waist and a pair of climbing irons. The woodpecker has the climbing irons—its toes—but no strap. To compensate for this deficiency it plants its wedge-shaped parson's nose firmly against the tree trunk, and with claws dug well in, leans back upon it, as confidently as does the earth-bound penguin or kangaroo.

An almost exact parallel to this is seen in the little arboreal scaly ant eater. Mounting a slippery palm trunk, it clasps it firmly with its hind limbs, and then leans back upon its long prickly tail with a tenacity that makes its dislodgment extremely difficult.

FIRST BACKBONED LAND ANIMALS

The body machine attached to the vertebral column was led into a variety of adventures once it had made its way to land. But before all its latent powers could be developed, certain vital changes were needed in its outer covering, which stood between it and the vagaries of climate.

The first vertebrate land animals were reptiles. Like their ancestors the fishes, most of them were probably covered with scales, and like the fishes were cold blooded. That is

to say, their bodily temperature was similar to that of the air or water around them. A rise of atmospheric temperature worked a corresponding excess of energy in the body machine; a fall in temperature caused its mechanism to slow down.

The truth of this can be readily appreciated by any one who keeps as pets, frogs, lizards, or the familiar goldfish. A fall in temperature renders all these creatures dull and sluggish, and finally comatose. A rise in temperature just as noticeably stimulates them to healthy appetite, and as a corollary, exuberant energy.

FEATHERS AND HAIR

When, towards the close of the Age of Reptiles, a period probably covering several hundreds of millions of years, the first mammals appeared, there is every reason to suppose they wore hair. The first birds wore feathers of a kind; feathers or hair are essential to maintaining a body temperature independent of climatic influences.

How a rise in the body temperature first came about is not exactly known, but it must have been manifested in those small pioneer beasts and birds who weathered the sudden fall in temperature heralding the Ice Age which swept into oblivion most of the giant reptiles and myriads of smaller species. The once almost universally genial climate which bathed our earth gave place to a cold which slowly crept northwards and southwards from the poles; the few surviving giant reptiles were



USES ITS TAIL AS A DOOR

LORIE LEIGH

The pangolin, or scaly ant eater, makes sure that its sleep will be undisturbed by blocking the entrance to its burrow with its bite-proof tail. Despite its reptilian scales, this West African is a true mammal.

herded within the equatorial belt, while a remnant of small and puny reptile forms lingered in temperate lands at the mercy of the growing band of furred and feathered new-comers.

BATHED IN NATURAL BRILLIANTINE

Hairs and feathers seldom leave satisfactory traces in the records of the rocks, so that their first beginnings still lie in the land of surmise. If, however, we picture scales becoming smaller and finer, splitting up perhaps from the edges inwards, we can at least form some conception of how feathers arose. Hairs are built upon a different basis, having roots with special glands surrounding them for their lubrication; they are bathed in a kind of natural brilliantine which keeps them supple. A bird's feathers are largely lubricated from twin oil reservoirs situated near the tail, and the bird has to ladle the oil on to the feathers with its beak.

We get a hint as to how hair or feathers may have arisen in certain fishes. There is in particular a South American catfish, the male of which carries quite an impressive beard round its lower jaw. The scales of that region are so split up that any one might be excused for regarding them, at first sight, as genuine hair.

Hair or feathers gave their wearers enormous



WIDE WORLD

SECRET OF THE RABBIT'S "BOB"

The rabbit's tail is too short for service as a tool or a blanket, but it has value as a sign.

M.O.L.—C

TRIBAL BADGE

Many antelopes and deer have their tails framed in a horseshoe of white, as a distinguishing mark.

advantages over the reptiles. Scales may keep out damp and resist coarse vegetation or the claws of enemies, but they offer scant resistance to cold. A mammal or bird "fluffs up" its fur or feathers automatically, and so creates a cold-resisting layer of air between itself and the outer temperature, much as does our cellular underclothing.

FEATHERS RESIST COLD

Human clothes may have become largely an expression of vanity, but with dwellers in cool temperate climes at least they are a necessity. We have lost the power to "fluff up" what little hair we have. When we experience "goose flesh" we are being reminded that nature is vainly endeavouring to raise our hair by tightening our skin, but there is scarcely any hair to raise.

The bird's feathers enable it to maintain a higher temperature than any mammal, and so survive greater cold. In this, feathers have played their part in the bird's mastery of the air, apart from their obvious conversion into propeller blades. Except for the spasmodic aerial adventures of bats and a few other small beasts, the mammals remain earthbound, but their hair still adapts itself to a vast number of varied requirements.

Hair generally responds very noticeably to

changes of temperature. Some animals, such as the sheep, if taken to cold countries grow a thin outer skin and long hair, but if transported to a hot country reverse these features. Very great cold is needed to lengthen the fur of some animals, which is why grey squirrels cannot be successfully farmed in England.

Interesting parallels to the sheep are the elephant and rhinoceros. Both these beasts once roamed the northern latitudes and grew dense coats of wool. Today they are confined

of the Alaskan musk ox, and cold will not lengthen that of the almost naked water buffalo. In steamy Burma is a small tribe of otherwise normal human beings so grotesquely hairy that they suggest enormous sheep dogs walking erect.

Long hair may generally be looked for in the polar regions and the tree tops, for when trees are tall enough those who haunt their summits meet with bitter nights. This accounts for the apparent inconsistency of the dense coats worn



WIDE WORLD

PROVIDED WITH A GRAPNEL TAIL

The marsupials known as opossums are found in many parts of America. Their diet includes fruit, birds and insects; and, because they live mainly in trees, most species are provided with long, naked, prehensile tails.

to warm countries, have grown thick outer skins, and have scarcely any hair at all. For some years in succession pygmy hippopotami belonging to the Zoological Society of London have been given a holiday at Whipsnade, which stands hundreds of feet higher than Regent's Park. At the close of the holiday, in early autumn, when there is a bite in the air, these beasts return to London with such few hairs as they possess noticeably increased in length, though not in numbers.

Hair growth is not entirely a matter of climate. In some instances it is controlled by heredity. No amount of heat will shorten the hair

by the Brazilian woolly monkey, and its mates of the jungle, the sloths.

Complete hairlessness can be produced by artificial selection, instances being certain dogs and cats found in China and Mexico.

The part hair plays in camouflage, courtship and other matters will be glanced at later. Here we will consider the hair itself and its modifications. It is but a step from hair to spines, and in a porcupine or hedgehog, or a tenrec shrew, one can see every intermediate stage between the two extremes. The porcupine's quills stand erect with terrific effect quite automatically when the wearer's skin goes

goosey in sudden alarm, but certain of these hairs can be put to other use besides discouraging foes. In the tail are certain large quills with hollow shafts and open ends which, when vibrated, give out a musical rattle, something like that of a rattlesnake. Opinion is divided on the origin of this device, but it may be intended as a warning.

NATURE PROVIDES A NAIL BRUSH

In South America abounds a guinea-pig-like rodent called the viscacha which excavates deep burrows in very adhesive earth. After a hard night's work the viscacha is in the condition of a navvy after some hours trenching in wet weather. But it soon makes itself spruce by means of its hind feet. One toe of each foot carries an arrangement of bristles exactly resembling a very stiff nail brush, a most effective cleansing implement.

Creatures like the porcupine and spiny tenrec have a certain amount of hair mixed up with their spines, but there are some few creatures in which the hair is almost completely confined to the underside. This seeming topsy-turvydom is accounted for by hair on the upper parts being rendered unnecessary owing to the extraordinary development of the skin. This is thrown into hard plates, as in the armadillo, or modified to form huge overlapping scales, a style of clothing which makes the scaly ant



R. KNIGHT (MONDIALE)

TAIL AS A LEG

The woodpecker and the kangaroo have at least one feature in common; both use their heels and tails in the same way to form a tripod.



ALL PUFFED-UP

This Turkistan owl has been frightened and has gone "goose-flesh," with the result that its feathers are on end.

eater or pangolins of Africa and Asia look far more like reptiles than mammals.

Nearly all beasts and many birds retain strong ridges of hair above the eyes, and numerous long hairs round the nose and lips. These are scientifically known as antennæ, more popularly as "whiskers," and serve as organs of feeling.

HAIR AS WEAPON

Strangest of all uses perhaps to which hair may be converted is the formation of a tool and a weapon by compression.

Nature has gathered together the hair upon the rhinoceros's nose to form the familiar "horn," a structure sometimes reaching a yard long, and equally serviceable for digging roots, guiding a refractory infant in the way it should go, or charging an enemy, which appears to be its primary avocation. True horn, it may be mentioned, such as tips our fingers and toes, surmounts the cow's head, forms the horse's hoof or encases the armadillo is simply an intensification of the skin, a corn become armour.

How hard a substance hairs may form if gathered in sufficient numbers and subjected to great pressure can be gathered from examining one of those "hair balls" which are sometimes found in the digestive systems of horses and cattle. These calculi may reach a foot in diameter, and can only be cut through with a sharp saw. They accumulate as the result of continually licking the coat.

WAR OF WITS

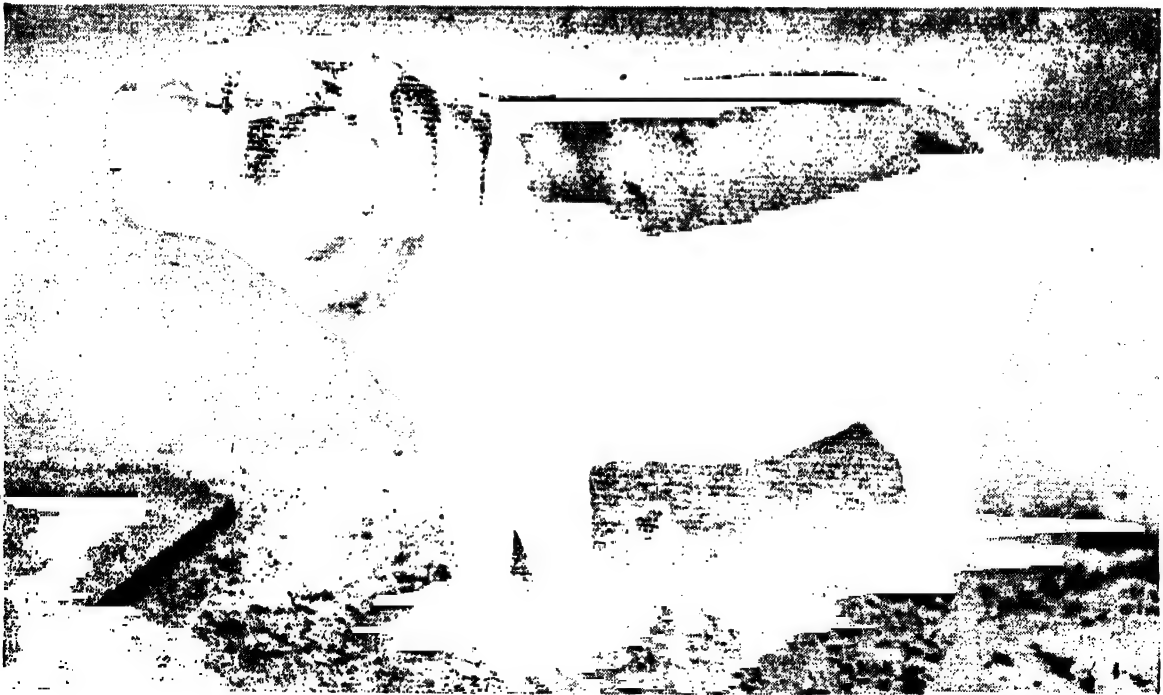
When the first birds and mammals brought into being body machines so much more complex than those of the reptiles, the latter far outnumbered the new-comers, and were often immeasurably their superiors in size and strength. Long before the encroaching cold came to the aid of bird and beast by wiping out the giants, the odds were on the smaller animals.

It has been suggested that they helped in the extinction of the dinosaurs by digging out and eating their eggs. This is more than likely, for the whole story of the mammals at least reads like the saga of a war of wits. They owe their present supremacy to a heightening of all the sensibilities, and with them, and as a natural corollary, of the intelligence.

The senses overlap, or merge together, and cannot very well be isolated; touch and hearing, taste and smell for instance are practically interchangeable. For example, if we pass a heap of burning refuse, we are not only very aware of the smell, but often of a noticeable "taste in the mouth." Similarly, when the Guards' band passes, the drums, that make conversation difficult, send a "thrill" up our coat sleeve or walking stick. The crash of a big gun feels like a slap in the face. Almost certainly one of the first senses to be acquired was that of touch. It must have been very active in those primitive scraps of life, the protozoa or animalcula, creatures quite devoid of sight or hearing.

FORFEITED FOR CIVILIZATION

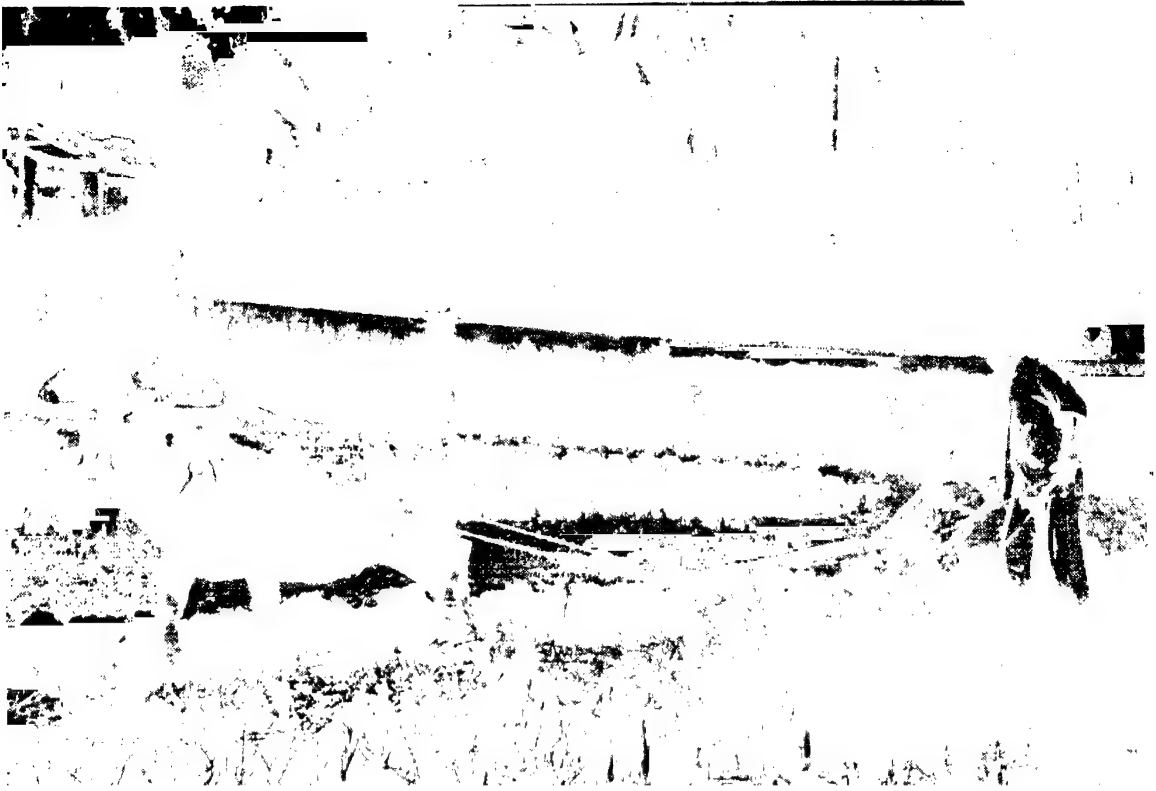
In the course of his development man, and especially civilized man, has largely forfeited some of the senses which mean so much to the lower animals, but almost every part of his system is acutely sensitive to touch, and by it he acquires impressions of every kind. His senses of smell and taste are called chemical senses, but they are still to a certain degree senses of touch. Particular organs receive the impact of molecules, infinitely minute particles



DR. GRAF ERDTWITZ (MONDIALE)

ALMOST BUT NOT ENTIRELY NAKED

The pigmy hippopotamus has a few hairs, relics of a distant past. Ordinarily these are not noticeable; but it has been observed that specimens kept at Whipsnade increased the length of their hairs with the approach of winter.



► PLOUGHING WITH A WATER BUFFALO IN HAWAII

The amount of hair an animal wears nearly always depends on climatic conditions, and increased output often follows migration to colder climes. In some cases heredity is the dominant factor; water buffaloes, for instance, remain naked in the coldest climate.

of chemical substances, which come to us from the surrounding air, or our food and drink.

Man has no great cause for self-congratulation as regards his nose. He has adorned or mutilated it at the dictates of fashion, but has allowed to sink into insignificance the function for which it was primarily intended, that of smell. Tea tasters and chemists still make some effort to preserve and cultivate the faculty, but such persons are in the minority. The human nose is of small account beside the eye and ear.

SMELL AND TASTE

To appreciate how intimately smell and taste are associated, one has only to securely close the nose, shut the eyes and then attempt to distinguish between such similar substances as beef and mutton, plain cake and bread, or pear and parsnip. Both senses can function only when moisture is present, so that minute particles of matter may impress themselves on the mucous membranes of the nose, or the taste buds at the back of the tongue.

There is no doubt that these senses are

present in the more primitive animals, insects, molluscs, and so on, but they vary much in degree, and often their seat is extremely problematic. A sense of smell seems sometimes to lie in an insect's antennæ or feelers, and also in the lobster's "horns." Taste in these creatures appears to be very crude; anything sweet or pungent will appeal to most insects, and putrefaction is apparently the lobster's ideal. A sea anemone will seize a pebble and even swallow it before finally rejecting it.

Even in vertebrates a sense of smell or taste is not confined to the nose and tongue. Some fish can taste by means of the finger-like barbels depending from the jaws; some can even smell through their breast fins.

EXPERIMENTS WITH FISHES

The appreciation of either flavours or odours may be deadened by drought or even extreme hunger. A bad cold puts our noses out of action, and very dry air also dulls its edge. Experiments with pollack at Plymouth Aquarium showed them to be hypersensitive



P. A. TAVERNER (MONDIALE)

AMERICAN PORCUPINE

Old-world porcupines have a certain amount of hair mixed up with their spines, but in American varieties hair sometimes completely covers the spines.

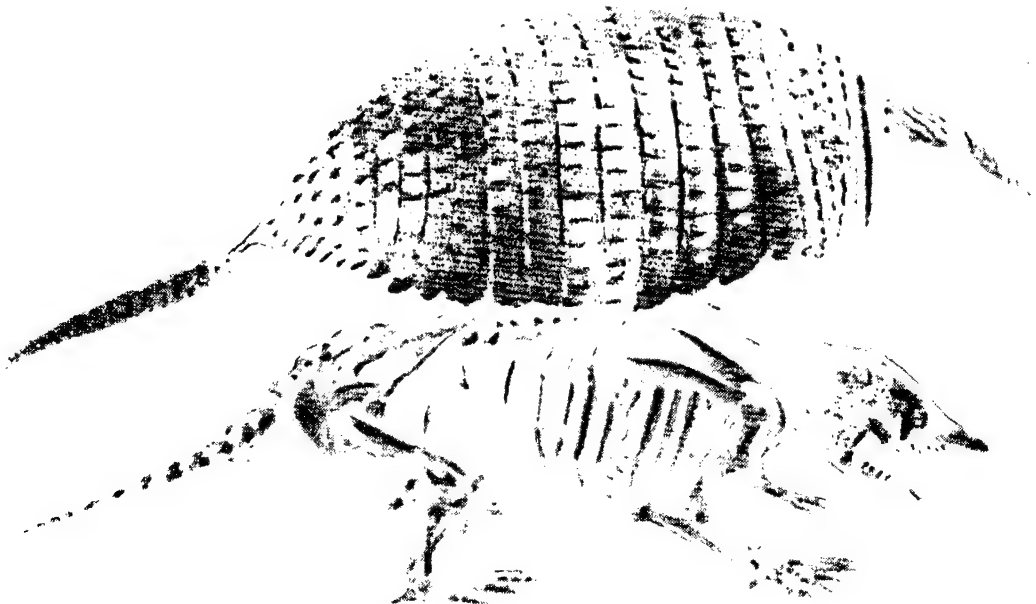
to odours when not particularly hungry, but when ravenous they showed complete approval of worms soaked in alcohol, paraffin and other non-appetizers. Isaac Walton records a cunning old angler who enjoyed wonderful success as the result of soaking his bait in oil distilled from ivy berries.

In the higher vertebrates, the reptiles, birds and mammals there is always present a tolerably well defined organ of smell, and by its size and position, as also by the so-called smelling bulbs of the brain, we can form a good idea of the creature's susceptibility to anything in the wind.

HOW SMELL IMPRESSIONS ARE RECEIVED

Lizards and crocodiles probably smell better than snakes, except for the remarkable egg-eating snake of South Africa. This reptile, with a head no larger than one's finger tip, can engulf a hen's egg, but it will rather starve than accept an egg ever so slightly stale. The sense of smell is at a low standard in birds, and finds its highest development in the kiwi, just as the parrot has the most delicately adjusted sense of taste, and the snipe and duck that of touch.

On the mammalian face the nose sits



HAROLD BASTIN

CAN ROLL ITSELF INTO A BALL

Since his body is covered with hard plates, the armadillo can dispense with the fur coats so many other animals find necessary. It is the only creature capable of rolling itself into an unwindable ball. Here the carapace or outer covering has been removed to show the skeleton.



HAROLD BAILEY

INSECTS' ORGANS OF SMELL

Top: antennæ of the may-bug or cockchafer. Middle: extended proboscis and antennæ of the oleander hawk-moth. Bottom: feathered antennæ of the male drinker moth. In its antennæ probably lies an insect's sense of smell.

enthroned. By its owner's standards it is often the crowning glory, at once a sense organ of rare receptivity, a tool and an adornment. In all mammalian noses there are two parallel chambers, each containing a cylindrical bone most delicately sculptured so that it suggests a sponge or intricate piece of filigree work. In the ox each of these bones is as big as a man's two fists. Over these spongy bones are spread the soft membranes upon which smell impressions are received and passed to the olfactory lobes of the brain—the odour office of the animal concerned.

SCENTED FOR MILES

Every hunter knows the importance of keeping to windward of his quarry, and many authentic tales are told of deer and arctic foxes scenting food or foes from a distance of several miles. Today the pig and dog are still employed to hunt truffles by scent. The dog's memory has been aptly likened to "a card index catalogue of smells."

The whale, though far from figuring at the lower end of the mammalian scale, makes the human nose seem by comparison a magnificent organ of smell. In a whale or porpoise the nostrils, placed on top of the head, are just convenient outlets for spent breath. As organs whereby to catch the odours in which the sea





W. S. HERRIDGE, F.Z.S. (MONDIALE)

FASTIDIOUS REPTILE

The egg-eating snake has a sense of smell so acute that it would starve before touching stale eggs.

must abound, they have virtually ceased to exist.

Man is the only animal to augment the natural beauties of his nose by adding paint and powder or piercing it with rings and quills. His next of kin, the monkeys, appear to be the only mammals who value a nose from the decorative standpoint, and amongst the monkeys "nose wear" is nearly always an exclusively male prerogative. A notable instance is the male mandrill's scarlet muzzle, set off by fluted cheeks of vivid azure.

STRETCHING THE ELEPHANT'S NOSE

The male proboscis monkey of Borneo starts life with a snub nose, but ends with a pendulous nose that must surely be an embarrassment at meal times. Almost as grotesque is the snub-nosed monkey of Asia, with a retroussé nasal organ pointing to the sky. Also unique in their way are the glaring white noses common to some of the guenon or face-making monkeys of Central Africa. It has been suggested, if not actually proved, that these noses, gleaming like traffic lights in the eternal twilight of the rain forests, help members of a troupe to keep each other in sight, on the principle of the rabbit's white "bob" and the deer's horse-shoe-marked rump.

Every mammalian nose is beautifully attuned to its owner's requirements. In Kipling's famous *Just-So Story* you will remember "the elephant's child" has his "mere smear nose" pulled out to trunk size by a crocodile and a

python, the one hauling at the tip, the other lashed to the elephant's hind legs and pulling in the opposite direction. The actual process of stretching the elephant's nose covered more than forty million years, and the most interesting feature of this wonderful adventure in facial adjustment is that the elephant was not alone in the endeavour. A host of other creatures were always striving in the same direction, but the elephant won the prize for the world's longest nose, and it appears as though he will retain it.

NOSE AS SAFETY DEVICE

Living pigs and tapirs are competitors in the great nose race, and the pigs in particular have made good progress. Once a crack is found in a macadam-paved yard, a wild pig will undertake to uproot the whole surface. This has happened in more than one zoo. The rhino's highly prehensile upper lip is a hint at the trunk's first beginnings; it almost exactly imitates what must have been the appearance of the upper lip in the moeritherium, the little hog-sized forerunner of the elephant.

In fossil beasts a study of the nasal bones permits experts to reconstruct accurately the nose that once covered them. Thus we know that in South America, a million or more years ago, something like trunks were developed by now vanished elephant monsters, big ungainly camels, and that strangest of all South American products, the giant sloth.

The modern moose of Canada and Alaska and the bizarre Saiga antelope are alone amongst living ruminants with trunk-like noses. No



PENCER ARNOLD

NOT MERELY ORNAMENTAL

The kiwi's nose is the most efficient olfactory organ to be found among birds. It is also useful for grubbing out insects.

doubt these are of some help in grasping foliage, but it is believed the primary intention of the downward projected nostrils is to exclude driven sand and ice particles from the delicate nasal cavity. The sea elephant's inflatable trunk is purely for ornament.

One detects strivings in the direction of a trunk amongst the various little insectivorous mammals, and such a structure must be of very practical service to a beast who lives by nosing out the unwilling worm and pill bug from its earthen retreat. The common shrew has a very trunk-like nose, for ever restlessly questing for food and tasting the air, just like the trunk of an elephant. The nose of the South African elephant shrew does actually dangle far below the chin, in approved Jumbo fashion.

MORE HINDRANCE THAN HELP

The moles, nearly related to the shrews, also develop long noses, the usefulness of which is easily understandable. The nose of the North American shrew-nosed mole, however, is something of an enigma. It is surrounded by a ring of more than a score of finger-like expansions that suggest more hindrance than help in excavating operations. Perhaps they have something in common with the extraordinary nasal appendages seen in so many bats.

Great Britain's native species have very normal faces, but some tropic kinds suggest the



BANDED ANT EATER

This Australian marsupial uses his nose for digging into ant hills. The American great ant eater and the South African aardvark are very similar.

ferocious masks of South Sea devil-dancers. The animal world offers no counterparts to these amazing fleshy appendages which often render the wearer's face unrecognizable as a face at all. Owing to the extreme difficulty of studying bat ways their use can only be surmised, and the most plausible suggestion is that they serve as crude aeriels which pick up vibrations or give warning of coming events hidden to the senses of sight, smell and hearing.

TONGUE NOT AN ORGAN OF TASTE

As already noticed, the tongue proper is not an organ of taste. Shut your eyes tightly, put out your tongue to its full extent, and get someone to drop a pinch of salt or pepper on the tip of it. Until you withdraw the tongue and bring the titbit in contact with your taste buds, it might be anything—dust or flour.

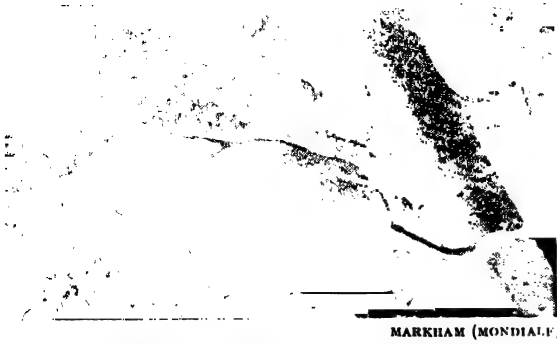
The tongue's job is to "handle" the food, to roll it into a bolus and then tip it backwards into the gullet. Next time sheep's head figures on your menu, look at the back of the tongue and you will see it is supported by a framework of quite large and solid bones, arranged somewhat in the form of a tuning-fork or a pair



WIDE WORLD

SEA ELEPHANT'S INFLATABLE TRUNK

The purpose of the inflatable trunk, or proboscis, of the sea elephant is entirely ornamental.



SHREW'S TRUNK-LIKE NOSE

The common shrew uses his nose as does the elephant his trunk. Both animals are ever searching for food.

of tongs. The prongs or handles are fitted on to the back of the skull, the whole embedded in powerful muscles that thrust the tongue in and out, like a piston.

TONGUE ANCHORED TO BREAST BONE

This arrangement is quite good enough for the general run of vertebrates, but there are some tongues which need to be thrust out so far that special kinds of roots are required to give them the right impetus. The ant eater's long worm-like tongue has roots anchored to its breast bone.

Woodpeckers and humming birds use the tongue either to extract insects from fissures

in bark and wood or to pick them daintily from the depths of large tropic bell flowers. For such work the tongue needs to be pushed out with great force, and in both these kinds of birds the roots of the tongue actually curl up over the back of the head and are fixed at the base of the bill, just between the eyes.

SPINES AS A STRAINER

Most mammalian tongues are soft and fleshy, but in those of cats the surface is covered with spikes for rasping away scraps of meat, and in many fish, and such fish-eating birds as penguins, the whole tongue is one mass of long spines used for preventing the escape of a slippery and unwilling mouthful, once it is seized.

Another wonderful tongue is that of the flamingo. In this bird the tongue fills the whole of the capacious beak, and is fringed with soft spines. The flamingo fills its mouth with mud and water, and using the tongue as a strainer forces the unwanted material out at the sides of the mouth, leaving only such shrimps and pond snails as the mud may contain.

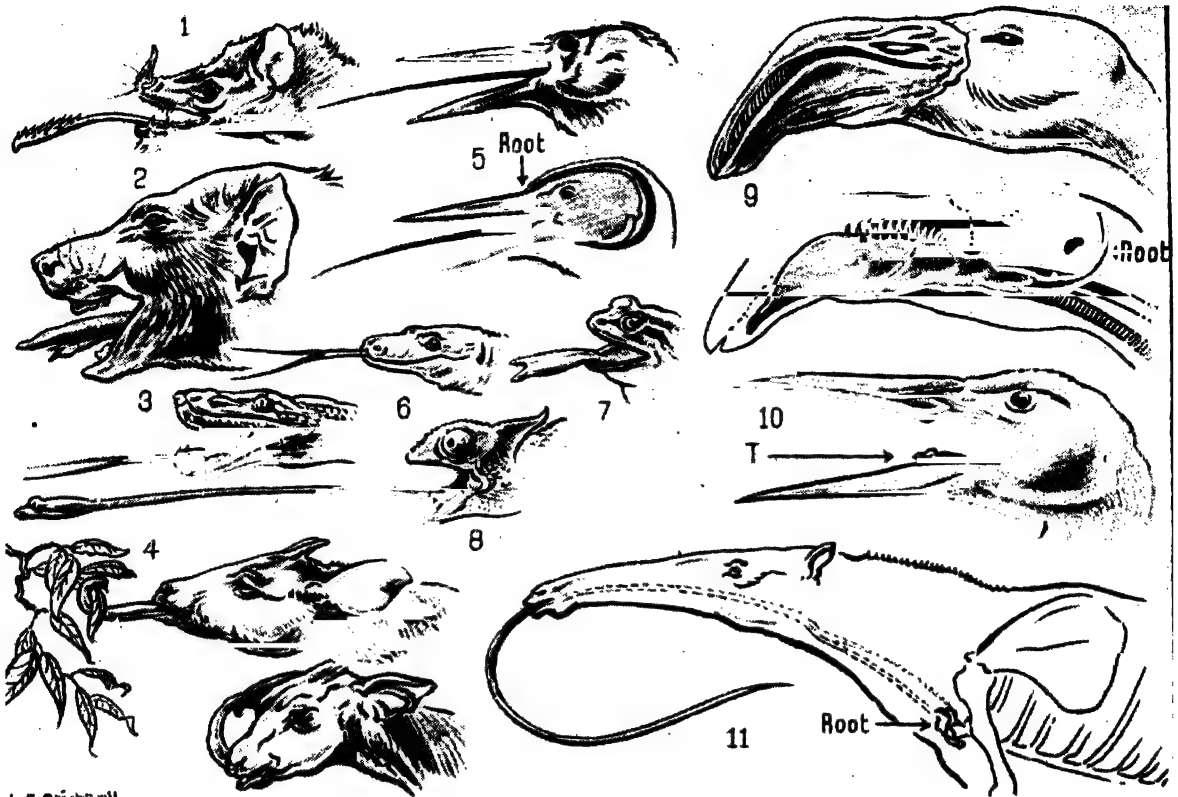
In the giraffe and sloth the tongue serves as a hand for grasping and tearing off bunches of leaves, and in one group of primates, the lemurs, it even acts as a toothpick. Lemurs have very fine and complex teeth, which easily



DR. PAUL WOLFF (MONDIALE)

LONG-TONGUED AND LONG-LEGGED FLAMINGOS

Fringed with soft spines and so long that it fills the capacious beak, the flamingo's tongue serves as a tool whereby to force unwanted material out of the sides of its mouth, leaving behind snails and the like.



TONGUES FOR EVERY PURPOSE

1. Tropical bat. 2. Double tongue of lemur. 3. Snake. 4. Okapi; used as leaf-picker and face-flannel. 5. Woodpecker. 6. Lizard. 7. Frog. 8. Chameleon. 9. Flamingo. 10. Gannet. 11. Ant eater; roots of tongue attached to breast bone.

collect pips from the animal's fruit diet or become clogged with hairs as the result of much grooming. On the underside of the tongue is what virtually serves as another tongue, smaller and with the tip frayed out to form a rake or comb, which being thrust between the teeth dislodges oddments, and so saves the teeth from decay.

WATCH-SPRING TONGUES

Many invertebrates have tongue-like organs which are worked on totally different principles from those controlling the tongues of casts, birds and reptiles. Moths and butterflies have long watch-spring tongues that can be shot out much as the "paper tongues" or "ladies' terrifiers" still popular on occasions of public rejoicing. Organs of impressive magnitude, they seem quite insignificant beside the wonderful ribbon tongues used by snails to rasp away vegetation or to eat out piecemeal some defenceless clam from the seeming security of its shell.

The tongue can easily be drawn out from a cooked limpet. It is a tough horny ribbon half as long again as the entire animal. A low-power microscope reveals it as being set with hundreds of teeth arranged in ranks and literally marching twelve abreast as the sea snail pushes its tongue over some weed-encrusted rock.

The common garden snail has one hundred and five teeth in each of its one hundred and thirty-five rows, making a total of fourteen thousand one hundred and seventy-five teeth.

OVER TWELVE THOUSAND TEETH

The common pond snail has over twelve thousand teeth. In squids and octopuses the "tongue-teeth" are in the form of a horny beak, exactly reproducing that of a parrot, but often much larger. They form a large part of ambergris, the valuable secretion found in the intestine of the sperm whale, which feeds on cuttlefish.

These examples by no means exhaust the possibilities of a tongue. Insect-eating creatures such as the chameleon and frog have adhesive tongues which literally act as fly papers. The chameleon's can be shot forth to a distance equalling its owner's length; the frog's worked with equal velocity reverses the normal arrangement of a tongue, for its roots are attached to the inner side of the lower lip, with the tip dangling down the amphibian's neck. When a fly is sighted the whole contraption completes a half circle, catches the insect, and then tosses it into the frog's interior.

Save in the chameleon, reptile tongues serve only one simple purpose, that of a probe. The forked tip goes in advance of the owner, exploring like the stick of a blind man.

SECRETS OF HEARING

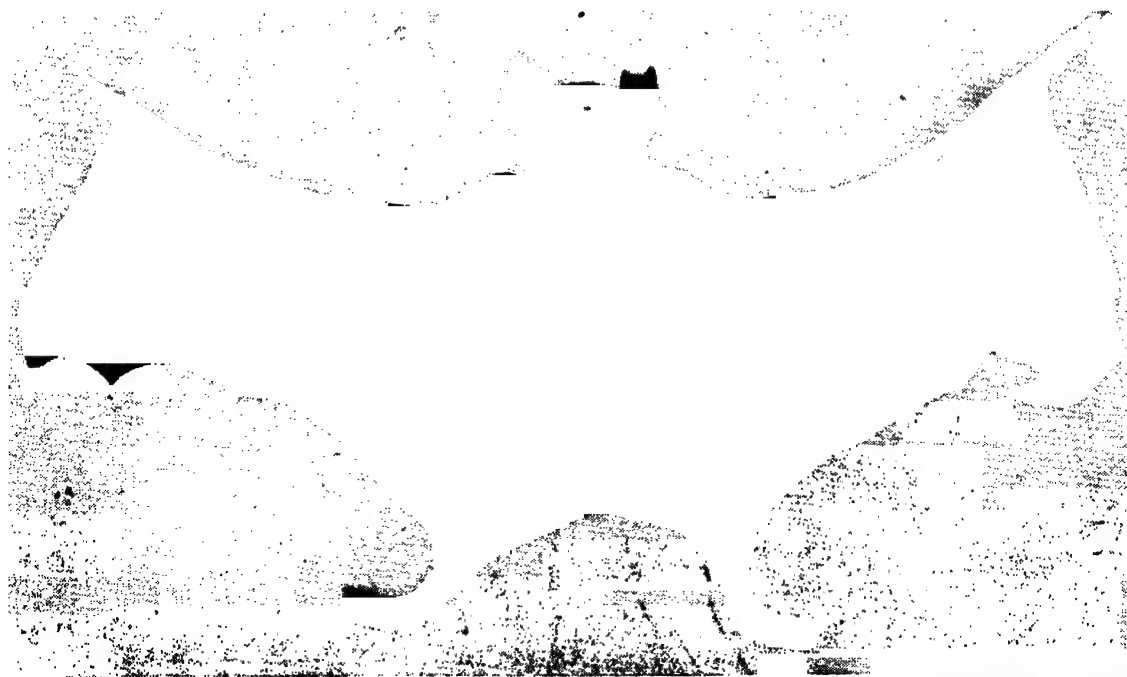
"He that hath ears to hear, let him hear," cried the Teacher of old, but science has given a wide implication to the term hearing, and vast numbers of animals hear without any ears at all. The line of demarcation between sound and touch is a fine one. Sound, as we understand the term, is the reception of certain vibrations agitating the atmosphere, and hearing is therefore a kind of feeling.

Receptivity to sound varies enormously, and in the appreciation of sounds, as in the appreciation of smells, some animals—the dog for instance—leave us far behind. The minute and complex bones of the inner ear pick up vibrations impinging on the drum, such apparatus being a vertebrate monopoly. But it is far from universal. In whales this contrivance is reduced to two big shell-like bones; sometimes each is as large as a man's two fists.

SOUNDS MAN CANNOT HEAR

Carnivorous beasts have the hearing installation contained in two big inflated bulbs, and it seems likely that such animals may be sensitive to sounds entirely lost upon the keenest human ears.

Snakes have no hearing apparatus at all, and the tuneless efforts on gourd flute of the so-called charmer are just a little piece of professional bluff. The snake really "dances" by following the rhythmic swayings of its charmer's body. In most bony fishes there are placed within the cranium two flattened bones, popularly termed ear bones, but as much concerned in maintaining the creature's balance as in responding to vibrations. Injury to one of these makes the fish swim lop-sided,



BLOOD-SUCKING VAMPIRE-BAT

W. S. BERRIDGE, F.Z.S. (MONDIALE)

In nothing are certain members of the bat tribe so remarkable as in their nasal appendages. Zoologists are in doubt concerning the evolution and uses of these organs. They may serve as aërials for picking up vibrations.



NOSES AND EARS IN RICH VARIETY

1. Bat. 2. Great ant eater. 3. Kiwi. 4. Pekinese spaniel. 5. Star-nosed mole. 6. Galago. 7. Long-eared owl; feathers turned back to show ear. 8. Echidna; hair turned back to show ear. 9. Blackbird; showing ear. 10. Frog. 11. Lizard.

and the reader may have noticed that some deaf persons have great trouble in maintaining their equilibrium on a bicycle.

The receptivity of fish to sound waves is still the subject of experiments. At the Plymouth Aquarium, for instance, a buzzer was installed in a food box within a tank, and various fishes soon learnt to rush to the spot as soon as the buzzer was set in motion. One young codling, however, having once grasped the significance of buzzer and box, took up permanent residence in the latter, presumably being determined to take no chance.

HEARING WITHOUT EARS

Hearing of a kind can be enjoyed without anything approximating to an ear as ordinarily understood. The osiphone was a device to give relief to the totally deaf, the apparatus being placed on the elbow, or even the back of the neck and so conveying vibrations to the afflicted person. During recent years Dr. Calman, of the British Museum, ascertained that lobsters possessed what he named auditory

hairs on certain limbs, which connected with special nerves and so transmitted vibrations in the water to the animal's brain.

Hearing is most unevenly dispensed amongst the insects. It is most noticeable, and not unnaturally, in species that themselves produce sounds. Grasshoppers and crickets have auditory drums on their thighs or other limbs, and the mosquito—principally the male—hears through its antennæ.

OUTWITTING THE MOSQUITO

The male mosquito is always listening for the high-pitched buzzing of his lady-love, but he is also attracted by the notes of a violin, the human voice, or the whine of a dynamo. This last susceptibility was turned by a clever engineer to the mosquito's undoing. He rigged up an electrically charged apparatus the song of which so pleased mosquitoes that they hurled themselves upon it and were straightway killed.

In the illustration are shown some typical outer ears of mammals, their size and shape sufficiently indicative of the wearer's hearing



FLY-PAPER TONGUE

HAROLD HASTIN

Frogs have adhesive tongues which act as fly papers. The roots are attached to the side of the lower lip.

capacities. Amongst the birds' ears the owl's easily take pride of place, and it is interesting to note how bird-like is the ear of that reptile-bird-beast the porcupine ant eater or echidna. The "psychic" aspects of animal hearing will be noticed later.

Sight, so vital a sense to ourselves and most mammals, is here placed last because it was probably the last of the senses to attain perfection. Until we come to the jointed animals and the mollusca, true sight is practically non-existent amongst the invertebrates. Worms, for instance, although sensitive to light, have no kind of seeing apparatus, neither have the starfishes and their allies, the anemones and jelly-fish, nor the countless hosts of the animalcula. Insects, with their often large and compound eyes, turning hundreds of facets to the world, probably have far keener sight than the crustacea.

TWO ROWS OF EYES

A crab is conscious only of dim shapes impinging on its retina, and so always assumes a fighting pose on the principle of safety first when confronted with almost any object, harmful or otherwise. In molluscs the seeing eye varies greatly. Octopods and cuttlefish, for example, have enormous hard, crystalline lenses, and from early times these have been

used for ornament or to garnish idols and mummies. The homely scallop bears on the fringes of its mantle two rows of gleaming eyes, presenting a wonderfully high state of development almost akin to mammalian eyes, but we must remember that the scallop has nothing which can be called a brain, and the images it receives therefore are comparable to nothing in our experience.

Not even the redoubtable Hawk-eye of the Mohicans could compete with the average bird in keenness of vision. Birds and some reptiles such as lizards have a marvellous range-finder in the eye, constructed on the principle of a camera's diaphragm. It is a series of bony plates, working one upon the other so that the aperture in their centre can be automatically increased or decreased as the exigencies of the moment demand.

PYTHON WITH A GLASS EYE

They reach a high development in the eagle and hawk, and their utmost capacity in the night hunting owls. Such eyes, however, were eclipsed by some gigantic lizards in the Age of Reptiles. These monsters had bony diaphragms measuring a foot or more in diameter.

In nocturnal mammals and some reptiles, the pupil, which lets in the light and with it the image to the retina, can be contracted to a slit when day demands a mitigating of the light. In this connection an amusing incident



WEAPONS OF THE PORCUPINE FISH

This formidable looking fish puffs itself up when attacked, and like its namesake erects its spines.

WIDE WORLD

occurred at a certain zoo when a large python, losing an eye by accident, was fitted with a glass substitute. As a result, night found the reptile with apparently normal eyes, but by day the living eye of course contracted its pupil, the false never budged, and so day and night conditions were reflected simultaneously.

The loss of pigmentation which causes albinos often extends to the eyes. The blood vessels, unprotected by colour from the light, give to the eye its peculiar red or pinkish appearance, such an eye being painfully sensitive to strong lights. A zoo monkey thus afflicted was continually shading its eyes with one hand until relief was found for it by fitting the beast with smoked spectacles.

Thus far we have glanced at a few of the more obvious externals in animal make-up, and the wonderful changes which Nature has rung upon the same organ in various creatures, according to their needs. We will now consider some more generalized uses to which almost any part of an animal may be put—the age-old matters of offence and defence.

WEAPONS IN NATURE'S ARMOURY

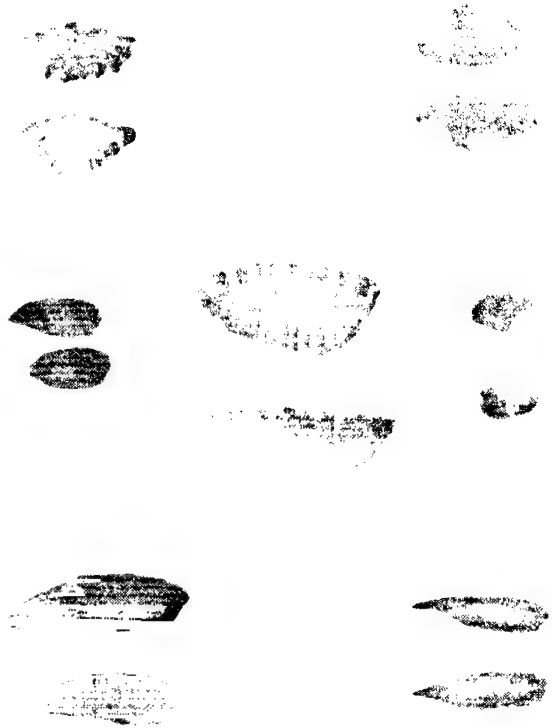
Almost any part of an animal may be converted into a weapon. Horns and hoofs, teeth and claws are among the more obvious weapons in Nature's armoury, and in tracing their development it is interesting to note that, just as in the story of human warfare, each succeeding instrument of death brought into being the means for its repulsion or evasion.



DISEASE BEARER

The mosquito hears sounds through its antennæ. The male hearing apparatus is extremely well-developed.

HAROLD BASTIN



HAROLD BASTIN

EAR BONES OF FISH

Situated within the cranium, these bones are as valuable in maintaining balance as for hearing.

Knightly armour became at last so heavy as to defeat its own purpose, and in a study of the geologic past the moralist might find abundant material for a lecture on the futility of armaments. There is little doubt that the horns and shields of some of the dinosaurs became at last almost too cumbrous to navigate. Nature seems to have evolved one monstrous device after another and scrapped it, when at last it reached its peak. Vast horns and tusks fell, one after another, before more lightly armed animals whose feeble weapons held the field rather by their skill in usage than by their own weight.

DEER IN CONFLICT

Even today we see animal weapons turned against their possessors. The deer's antlers are exceedingly tough and springy, and when two bucks meet in conflict the horns easily become so interlocked that death by starvation or at the teeth and claws of wandering carnivores overtakes both champions.

Many of our most modern weapons were anticipated by Nature hundreds of millions of



DR. GRAF ZEDTWITZ (MONDIALE)

FATAL LURE OF THE BEAUTIFUL SEA ANEMONE

Though it shows no signs of knowing it, this fish is about to die. Within a few seconds the anemone's nettle-capsules will explode and harpoons will shoot out on long white threads to pierce the victim.

years before mankind appeared. The hollow-bodied sea anemones, jelly-fish, etc., sting, but their stings—crowding the delicate tentacles—have no analogy to the irritant hairs of nettles.

HOW JELLY-FISH STING

A high-power microscope reveals each sting as a barbed dart, with sharp flukes, folded close to a shaft to which is attached a neatly coiled line. Contact with a foe touches off the whole apparatus by means of a hair-trigger, and the barbed dart, suddenly expanded, plunges into living tissue. Shaft and line are dragged after it, and when hundreds of such darts find their way into a bather's blood stream, as when he collides with a big jelly-fish, it is small wonder he later suffers from irritant blisters. This fiendish little weapon largely parallels the gun and harpoon mounted on the prow of every whaler.

Some anemones fling out their darts in the form of long white threads, each charged with its little harpoons and coiled lines. Such threads will pour out at the sides of the common parasitic anemone always found on whelk shells tenanted by hermit crabs. Threads of

another kind form the weapons of the big black sea cucumber, sometimes found in rock fissures at extreme low tide.

Disturb one of this kind and yards of long white threads shoot out from its hinder end, suggesting the streamers we use at jollifications. But the sea cucumber's streamers are elastic and adhesive, and a big lobster once involved amongst them is rendered impotent, bound claw, legs and tail past all possibility of movement. It takes an hour or more for the threads to rot, and by the time the lobster, if not suffocated, regains its freedom, the antagonist has leisurely crawled to safety.

BEEETLES THAT USE GAS

The throwing of missiles is an art that does not reach its highest perfection amongst monkeys. There are certain soldier white ants or termites that squirt fluid at a foe, the said fluid hardening on contact with the air so that a luckless spider thus sprayed is literally petrified. A tiny lizard of the Californian deserts squirts blood from the corner of each eye, and several mammals beside the skunk can eject nauseating fluids.



HAROLD RASTIN

MARINE LODGING-HOUSE WITH MANY TENANTS

Numerous animals making use of the house left by a whelk. Inside is a hermit crab, and on the outer walls tenaciously cling two sea anemones (one large, one small) and numbers of barnacles and worm-tubes.

Explosives would appear to be the secret of one class of creatures only, a family of small and obscure beetles that have earned the title of bombardiers. Several species are native to Great Britain, and if disturbed, as by upturning a stone beneath which they may be hiding, amaze the obtruder with a volley of sharp pops followed by little puffs of acrid smoke. The beetle ejects a drop of volatile fluid which ignites on contact with the air, and a well-aimed discharge may lay a big cockroach on its back.

FISH WITH WATER GUN

One fish at least has evolved the water gun, but rather as a legitimate means of livelihood than as a weapon pure and simple. The little Malayan archer fish squirts a jet of water from its spout-shaped lips at any chance fly perching on water-side vegetation, and the insect, fairly struck, is quickly engulfed as it falls upon the surface of the water. Rarely does the archer fail to hit the target.

Poisons of all kinds are widely distributed

throughout the animal world. Many of us have had first-hand experience of insect poisons such as those of the ant, which consists largely of formic acid, or of the mosquito, bee and wasp. In the last mentioned the poison is conveyed from two glands, one containing an alkaline, the other an acid fluid.

SPIDERS KILL BY POISON

All spiders kill their prey by means of poison injected through their hollow fangs, but only the venom of a few large tropical species affects human beings. In the mollusca, poison glands and fangs are confined to one family of sea snails, the gorgeous cones of tropic waters, and their venom may have serious, though never fatal consequences.

Amongst the vertebrates quite a number of fishes carry poison glands, notably various sharks, the notorious sting rays, the chimæras, the North American catfishes known as mad-toms, and the weever fish. Two kinds of weever fish are found in England, the great weever measuring over a foot and the lesser



weever of only a few inches long. The latter abounds in sandy bays, and carries hollow spines on its gill covers and back fin which connect with poison glands. If a person bathing treads on one of these fish as it lies half buried in the sand a very painful wound results.

The dangerous qualities of these little fish must have been known long ago, for the name is derived from the Latin *vipera*, signifying a viper or a serpent. One sometimes sees the notice "'Ware Weevers" displayed on pier heads; and in France, where the big weever is commonly eaten, a special law has been passed enforcing the removal of the spines before the fish is exposed for sale.

SNAKE TOLL OF HUMAN LIVES

Most of the amphibians, such as newts and toads, exude poisonous secretion in the warty protruberances covering their skins, and even today the newt and toad have bad names in some remote country districts. Normally one suffers no inconvenience from handling these otherwise harmless creatures, but experiment has shown that if their secretions enter a cut or the mouth very painful results follow, and the fluids when injected under the skins of small mammals even cause death. Anyone who has seen a dog confronted with a toad, will have guessed the latter has something about it which renders it a highly distasteful mouthful.

About one-third of the one thousand five hundred-odd species of snakes now living are poisonous in varying degree. The viper, found in Great Britain, inflicts no more than half a dozen "stings" on human beings perhaps in the course of a year, although its venom is more often than not fatal to dogs. In contrast to this, the kraits and cobras of India alone account for some twenty thousand human lives annually.

ONE VENOMOUS LIZARD

The poison is derived from specially modified salivary glands, forming two large almond-shaped bodies, one on either side of the head. In a few snakes, such as the night adders, they extend down the interior as far as the heart.

Always the poison is injected through hollow teeth in the upper jaw, usually by a lightning stroke or a chewing action. A few snakes actually squirt the venom from their fangs, a notorious example being that of the deadly South African spitting cobra or ring-hals. Its venom invariably causes blindness if it enters



HAROLD BASTIN

EIGHT EYES AND EIGHT LEGS

Top: Golden spider trussing-up a grasshopper, which ventured near its web. **Bottom:** House spider. Its eight eyes enable it to see in more than one direction at once. In the background are its eight legs. All spiders kill their prey by means of poison injected through their hollow fangs.



HAROLD BASTIN

REPTILIAN WEAPONS

Above: Skull of the hamadryad, showing poison fang. Top right: Adder's head. The mouth is open with the lower mandible pulled back to reveal position of poison glands. The adder is the only venomous snake in Great Britain. It is able to inject poison six times before its reserves are exhausted. Bottom right: Head of common grass-snake. It is non-poisonous.



the eyes, and should it penetrate a cut, death follows in an hour or two. Only one venomous lizard is known, the Gila monster or heloderm of Arizona. It possesses glands and fangs like those of a snake, but rarely if ever causes human fatalities.

Electricity played its part in the World War, and is a recognized instrument of death in the penal codes of several countries. In Nature its use as a weapon seems to be confined to fishes, having been evolved by several quite unrelated groups, each having batteries in an entirely different portion of the system. The outstanding electrical fishes are the electric eel, which is only eel-like in general shape, the electric catfish, and various skates and rays.

FISHES THAT GENERATE ELECTRICITY

The so-called eel of Brazilian waters has the tail muscles—which constitute four-fifths of the body—converted into powerful batteries, a six-foot eel being able to give a shock of several hundred volts. At New York Aquarium one of these fishes was used to light an aeroplane beacon, ring a bell, and even launch an aeroplane.

The catfish of Arabia has the entire body wall converted into an electric organ, the fish being invested with one big battery as with a garment. It uses this weapon, not like most electric fish to stun its prey but to shock other

fishes into disgorging their meals, which it appropriates. Something like this is seen in the unattractive diet of the Squa gull, which forces other birds to disgorge by the cruder methods of mere bullying.

The electric rays, common in all warm seas, often visit English waters during a heat wave, and signify their presence to anyone treading on them as they lie buried in sand in a very dramatic manner. The French very aptly call this fish "M'sieur Touchez." A big electric or torpedo ray can give a shock of about thirty volts, the batteries being arranged in the form of hexagonal cylinders laid out vertically in two groups, one on either side of the body. When a fish, such as a grey mullet, swims unsuspectingly above a half-concealed torpedo, the latter rises, "shocks" the mullet by deliberately cannoning into it, and then engulfs the prize before it can recover.

MASSAGE BY TORPEDO RAY

In olden times the torpedo ray was made to furnish a crude form of vibro-massage, rheumatic sufferers being required to stand bare-footed on the fish as long as the medical adviser or their own powers of endurance dictated. At Brighton many years ago a wily old longshoreman happening to catch a big torpedo, exhibited it as a catch-penny device

by inviting all and sundry to "guess its weight." Nobody held the fish long enough to form an opinion until a knowledgeable bystander picked up the fish by the tip of its tail, the only insulated portion.

The phrenologist has rushed in where science fears to tread. He has mapped out the brain into certain well defined areas, each of which he claims to be in charge of some particular attribute—courage, religious zeal, artistic capacity, and so on. To the scientific brain specialist the mass of nervous tissue controlling an animal organism is still largely an uncharted sea, full of mysterious currents and unplumbed depths.

No mechanism, natural or man-made, can even approach the brain in intricacy or subtlety. We will here attempt only to point out the varying capacity of the brain, and the work it can do. Many of the misunderstandings and heated controversies of our times are the result of misconceptions concerning animal mentality as opposed to human.

BIG AND LITTLE BRAINS

In the two great divisions of the animal world, the vertebrates and the invertebrates, the mammals on the one hand and the insects on the other, have outstripped all competitors. Although the insects immeasurably exceed all other invertebrates in their varied ways of life and organizations, which often seem to mimic our own, their mental capacities are exceedingly limited—by their size. The largest insect has an infinitely smaller brain than the tiniest fish. As a result the insect brain works within the narrowest limits; it is like a machine fashioned to do certain things, and those only.

When the unforeseen happens, or initiative is called for, one might as well expect the insect

brain to rise to the occasion as one might expect a sausage machine to suddenly take on the task of a typewriter. Faced with a crisis the insect still blunders on in the same rut it followed when all was well.

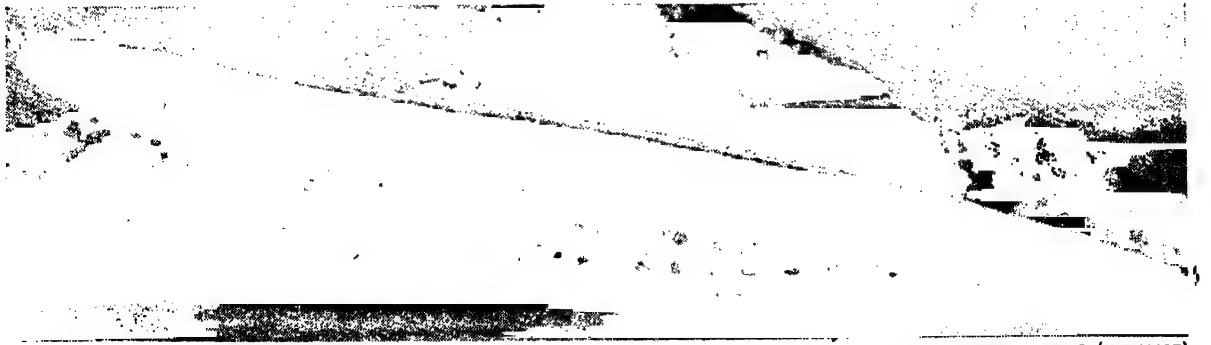
If a wasp is cut in half, the forward portion continues to feed. If a cockroach be decapitated, the jaws still bite at any food within reach, and the headless body continues to go about its business, walking and even flying until, being unable to take in more fuel owing to the loss of its head, the mechanism finally runs down.

BRAIN CAPACITY

Initiative, adaptability to altered circumstances, manifests itself in even the lowest vertebrates, and increases proportionally with increase of brain capacity as we ascend the scale. In judging the brain capacity of mammals, one may easily form a false judgment if guided by external appearances only. Many an impressive "dome of thought" owes its seeming bulk, not to the brains within but to hollow bony structures giving the skull strength combined with tightness, or to huge masses of muscular tissue animating the jaws.

An X-ray view of the brains of familiar animals would come as a surprise to some. Man, for example, heads the list with a brain roughly one-sixtieth his own weight. He is easily the brainiest creature for his size the world has ever known. The chimpanzee, his next of kin, has a brain only one-third the human weight. The elephant, despite the portentously brainy appearance of its great head, has a brain less than one six-hundredth its body weight.

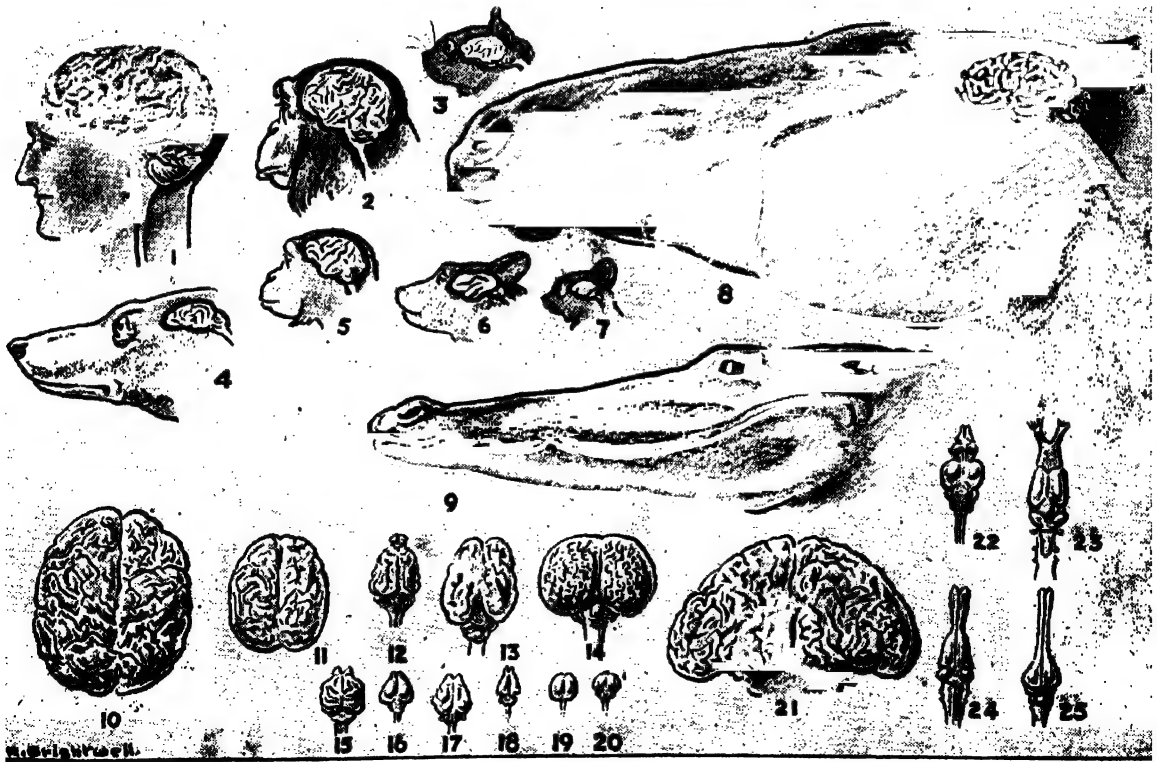
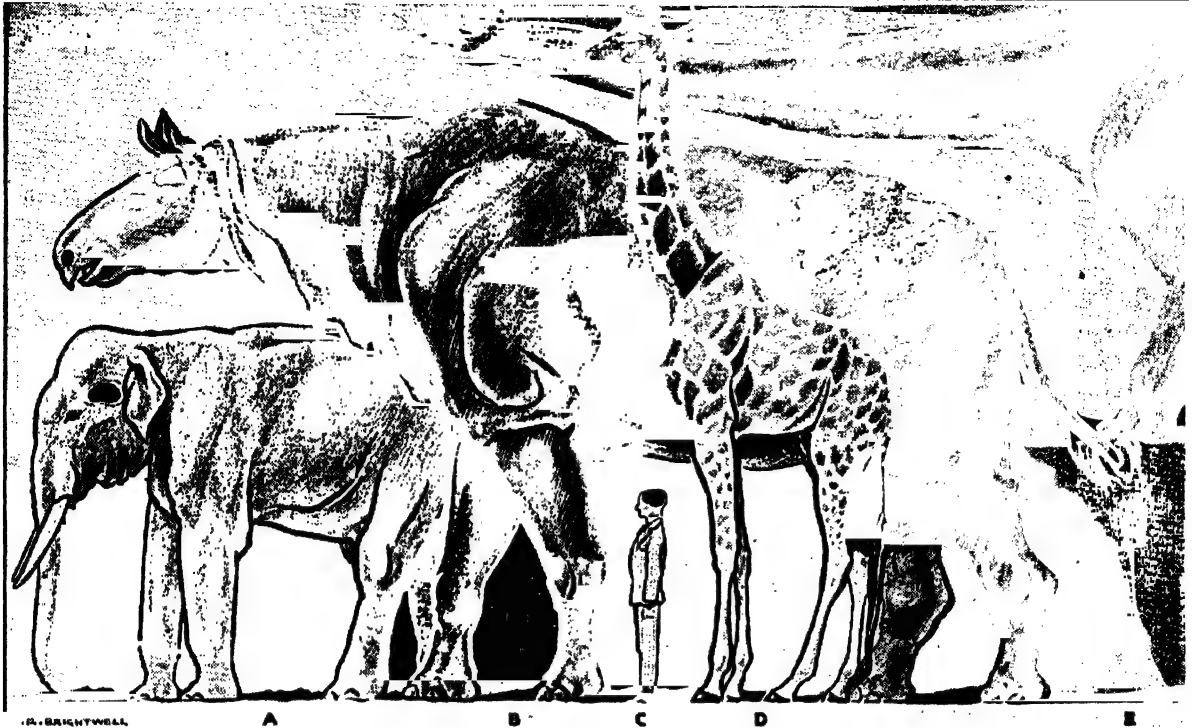
The domestic cat, though so much the lion's inferior in size, has a proportionately much



EEL THAT GIVES POWERFUL ELECTRIC SHOCKS

The electric eel, found in the swamps of Brazil and Gulana, is not an eel, but it certainly is electric, since it is capable of giving a shock that will stun a horse. Other "electric" species give lesser shocks.

W. S. BERRIDGE, F.Z.S. (MONDIALE)



BRAIN VERSUS BRAINS

- A. Elephant. B. Baluchitherium. C. Civilized man. D. Giraffe. E. Brontosaurus. 1. Man. 2. Chimpanzee. 3. Cat. 4. Dog. 5. Monkey. 6. Lemur. 7. Tarsier. 8. Horse. 9. Crocodile. 10. Man. 11. Chimpanzee. 12. Dog. 13. Ox. 14. Porpoise. 15. Echidna. 16. Duckbill. 17. Kangaroo. 18. Rabbit. 19. Marmoset. 20. Pigeon. 21. Elephant. 22. Salmon. 23. Frog. 24. Lizard. 25. Alligator.

larger brain. The horse, in spite of being almost humanized by some of its admirers, cuts a poor figure in the gallery of brains beside the average dog.

Human brains show great uniformity of weight, though apparently so variable in quality. The guide book to the College of Surgeons Museum in London, describes a cast of the brain cavity of Dean Swift there displayed as "of mediocre size and common



HAROLD HASTIN

DO INSECTS FEEL PAIN?

Capacity to feel pain depends on brain-power. This wasp having lost his posterior half, continues to eat.

shape, quite unlike the products of the brain which the cast represents." It is also pointed out that "many more brains of men with specially developed faculties must be preserved for investigation before any definite statement can be made as to a relationship between any particular part of the brain and the manifestation of a particular faculty."

There are solid grounds for believing that the general area of the brain offers a clue to mental capacity. The greater the number of creases or convolutions into which a brain is thrown, the larger the area it would cover supposing it could be spread out flat. There is a marked decrease in the brain's convolutions

as we descend the vertebrate scale. We pass from man's complex brain by almost imperceptible degrees to a mere blobbiness, and one cannot fail to be struck by the curious uniformity of birds' brains, and their close similarity to those of some reptile.

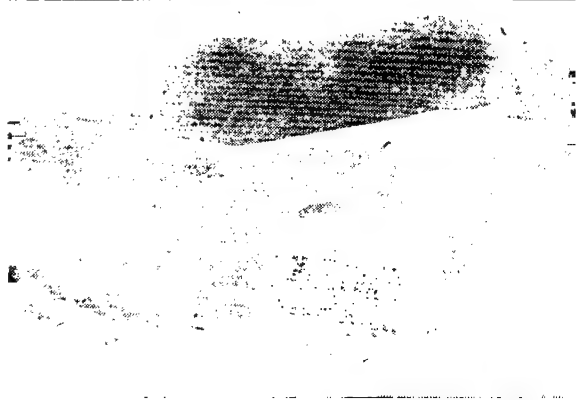
As in all other matters appertaining to Nature, we are here confronted with some seeming contradictions and paradoxes. Whales have brains rivalling that of man in complexity, and the brain of the common porpoise, a "pocket whale," is relatively heavier. The little squirrel monkey and the marmoset have slightly bigger brains for their size than has a man, but must be of inferior quality, judging by the owners' general deportment.

BRAIN AND PAIN

The brain animates and directs the body, and tells the animal when the body is in trouble by registering those signals from the nerves which we call pain. Pain is appreciable in direct proportion to the brain power.

Failure to appreciate this simple principle still gives rise to endless controversy concerning sport, the use of animals in medicine, and many other matters. There are still plenty of well-meaning persons who put guinea-pigs, goldfish and butterflies on a mental level with human beings. Where an animal, such as a rat, renders itself unpopular, sympathy is less apparent.

Equally muddled are many persons' conceptions of cruelty as evinced in the lower animals. A cat playing with a mouse, or a tiger toying with a wounded man, are placed almost on a level with sadistic Nero. Cruelty, the conscious and deliberate causation of pain, is a sole monopoly of adult, responsible humanity.



RAY PALMER (MONDIALE)

GREAT WATER SCORPION

The insect brain is like a machine fashioned to perform certain functions, and those only.



BADGER'S COAT IS DARKER BELOW

WIDE WORLD

The badger is one of the animals, like the skunks and the pandas, which reverse the usual coloration-practice in having the under parts of their coats darker than the upper parts. This makes them conspicuous.

to a certain extent, and so can many lizards.

How the chameleon earned world fame as a quick-change artist must remain a matter for surprise. It is far surpassed by many other lizards, and all kinds of molluscs and insects. Exhaustive experiments conducted at the New York Zoo made the promoters wonder how

face-making effect, which is believed to "hypnotize" the bird into immobility.

Colour plays a great part in camouflage, and is doubly effective when aided by form. The python in the jungle might well pass for a lichen-encrusted, sunlight-flecked tree branch. In this connection it may be mentioned that forest animals on a

CAMOUFLAGE AND COLOUR IN THE WILD

To human spectators colour goes far to make the pageant of life the never palling spectacle it is. But colour as such is not always so significant to the lower animals, colourful though they themselves often are. A very large number are, in varying degree, colour blind. They live in a photographic world. To such, however, pattern still has a meaning, which accounts for the often striking designs which many colour blind creatures present in their markings.

In this matter of colouring, the human anxiety to find a reason for everything is not always easily satisfied. Why, for example, should so many desert animals be sand-coloured? The obvious answer of course is concealment, but here we meet with a difficulty. Many desert animals that might well seek concealment are quite strikingly coloured, and others again are nocturnal, so that their camouflage seems wasted.

When we consider another class of creatures living in very uniform surroundings, namely

the stygian blackness of the ocean deeps, the case is more understandable. Black and red, by absorbing so much light, both appear black in the darkness, and hence it is that many very diverse abyssal animals are either red or a uniform black. Very often indeed animal coloration makes for concealment.

Uniform coloration harmonizing with a similar background need not necessarily constitute a cloak of invisibility. Light from above casts a shadow not only on the ground but on the creature's underside, thus rendering it conspicuous enough. To counter this the back must be darker than the belly, so nullifying the effect of the light and the shadow it casts. This is a very general principle in the coloration of a large number of creatures, both vertebrate and invertebrate.

In the surface waters of the sea, and also to a lesser extent of lakes and rivers, there swarm the larval forms of all manner of animals—fish, crustacea, molluscs, worms and so on. Science, as already noted, calls this medley by

larger brain. The horse, in spite of being almost humanized by some of its admirers, cuts a poor figure in the gallery of brains beside the average dog.

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Giant panda, representing the giant panda, and the raccoon, has an unusual colour-scheme.

floor. It is then that, gradually, pigmentation shows itself, first in scattered spots which, increasing slowly, merge and invest the creature's entire body. Those which elect to live always at the surface acquire prevailing tints of blue. Jelly-fishes, such as the Portuguese man-o'-war, are typical of this surface fauna.

SPENDING LIFE UPSIDE DOWN

Light is an essential to rich and varied colouring, and it is noticeable that shells tend to be most pigmented on the upper surface. But in the open sea there is a sea snail which reverses the normal snail behaviour. Instead of crawling on its belly foot with the spire of the shell pointing upwards, the violet snail floats throughout life with the mouth of the shell directed skywards. This portion is suffused a lovely violet, which fades to whitey blue towards the spire.

On Egyptian friezes a curious fish is often depicted swimming upside down. This is perfectly correct, and the fish in question is still

as we descend the vertebrate scale. We pass from man's complex brain by almost imperceptible degrees to a mere blobbiness, and one cannot fail to be struck by the curious uniformity of birds' brains, and their close similarity to those of some reptile.

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There can be little doubt that birds have a very lively colour sense. In no way else can we explain such dresses as those of the peacock, the various cock pheasants and male birds of paradise. Where colour is wanting, the bird often finds means to lure a mate by song; it is seldom that we find both attractions in one and the same bird.

Colour again can have a warning significance. "Hands off" says the wasp's gaudy attire of black and gold. Yellow is a very prevalent warning colour. The skunk walks abroad clearly labelled an untouchable, and so also do the caterpillars of the cinaba moth, and to a lesser degree those of the swallowtail butterfly. The cinaba moth itself is conspicuous in its dark blue spotted a lurid pink, and as with its caterpillar, no bird will touch it twice.

Save for seasonal changes, the colouring of mammals and birds is constant, but amongst the lower vertebrates and invertebrates this is reversed, often in dramatic fashion. The little green tree frog can blend with its surroundings



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WIDE WORLD

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Very different are the responses shown by certain common flat fish such as the sole and dab. If made to swim from a sandy floor, where they are invisible, on to an area marked in geometric patterns of black and white, the fishes become one with their surroundings in a few minutes.

HYPNOTISM IN NATURE

Fear, hunger, rage or other emotion, produces just as startling changes in many other kinds of fish. In the John Dory a vivid streak appears down the centre of the fish's face when food appears, and it has been suggested that this holds the attention of a prawn until the dory can engulf it. Still more striking is the way in which some tree snakes have the tongue coloured uniformly with the head. When a bird or other prey is sighted the tongue is shot back and forth, producing an extraordinary

face-making effect, which is believed to "hypnotize" the bird into immobility.

Colour plays a great part in camouflage, and is doubly effective when aided by form. The python in the jungle might well pass for a lichen-encrusted, sunlight-flecked tree branch. In this connection it may be mentioned that forest animals tend to present light spots on a dark ground, simulating the play of sunlight through leaves, whilst dark spots on a light ground are the rule with plains-dwelling animals, especially on pebble-strewn areas. Stripes blend well with sunlit grass; the tiger and zebra are obvious examples of this type of protective coloration.

RESEMBLING THE DESERT

Some desert lizards, like the Australian moloch and the Mexican toad, both clad in dense coats of sharp spines, are absolutely indistinguishable from the sun-baked sand sprinkled with dry thorn scrub or splinters of quartz and hornblende.

The shores of Great Britain provide some of Nature's most perfectly camouflaged animals. The word camouflage, be it noted, means literally a disguise, and is comparable with camouflet, signifying a puff of smoke in the face, in which connection its war-time application is sufficiently apparent. In summer the octopus visits England's shores, and no creature is more difficult to detect upon a weedy and rocky sea bed. It can dilate certain pigment cells and contract others so

that an immense range of colour changes is at its command, rendering it adaptable to almost any environment.

Many fishes have exaggerated fins or special embellishments of skin which perfectly simulate weeds. In the common angler fish even the eyes are so marked as to counterfeit the starry sea squirt which encrusts weeds and stones. Some tropic sea horses are literally lost amongst their voluminous decorations. One sees the

cuttings of sea weeds and corallines, chew the ends to give them better purchase, and then affix them amongst the hairs on carapace and limbs, where they take root, and in time entirely conceal the gardener.

This is not all. The crab shows minute discretion in making its fancy dress blend with its surroundings. If a crab dressed in red weeds be placed in a tank filled with green sea plants, the old dress is methodically removed and a green camouflage substituted. Instead of hooked hairs some of the spider crabs have a "pipe-clay" surface to the shell which gives an ideal anchorage to the sponges which these crustaceans use exclusively in their "make-up." When neither weeds nor sponges are available, pebbles may be laboriously piled upon the back.

DRESSING-UP BY CHANCE

When vertebrates dress up it is the result of chance rather than of premeditation. The sloth acquires a powdering of lichens; the mud turtle and limpet gather vegetable growths as the result of their sedentary lives. The only case of dressing up analogous to that of the spider crabs is seen in a family of tropical sea snails known as carrier shells. Like other molluscs these add to their shells by means of superimposed layers of limy secretion. But the carriers show originality in that they incorporate bits of the ground they live on with the cement, and shell collectors divide them into mineralogists and conchologists according to the nature of their disguise. In either case it blends perfectly with local scenery.

NATURE AND THE WORLD WAR

Self-contained camouflage resolves itself chiefly into breaking up the animal's outline with a dazzle pattern. Thayer, the animal artist, may be regarded as the originator of that complex system of camouflage which the World War brought into daily life. We painted ships much as the killer whale and sea unicorn are marked, and even took a hint from the spider crabs, when we covered guns and ammunition dumps with netting sewn all over with scraps of green and brown rag.

The essence of a camouflage dress is to make its wearer look like something else. A very common form is plant imitation. The leaf butterfly of India even shows holes and mould spots on its wings, which in shape perfectly counterfeit leaves even to the stalk. The South American leaf fish has a stalk-shaped nose, and

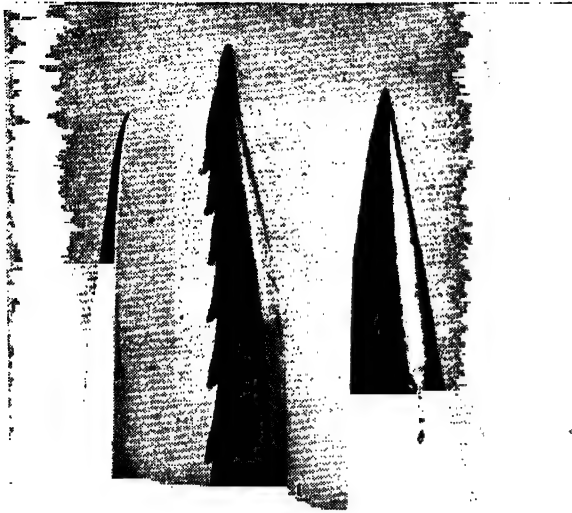


HIGHLY-COLOURED BIRDS

Male peacocks cannot charm their mates by song, but they do so with bright colours and will fight for the possession of a desired hen.

same principle at work on every hand. Sea slugs counterfeit the anemones on which they feed. Anemones mimic gravel beds and coral-lines; crabs, worms and shells pass themselves off as almost anything but what they are.

In the spider crabs we meet an amazing degree of what may be designated artifice, amazing since they have no brain comparable to those of even the lowest vertebrates. These crabs have rugged shells covered with hooked bristles. The animals very deliberately take



spends much time drifting sideways or standing on its head, in which posture not one man in a hundred would suspect its true nature.

Stick insects perfectly suggest dead twigs in their every feature, and the leaf insect not only turns from green to brown in autumn, but lays eggs so like plant seeds as to deceive the expert botanist. The leaf insect's colouring, like that of the bright green bones of the garfish, is due, not as is normal in animals to pigment, but to chlorophyll, the prevalent colouring matter of plants. Some few insects like the tropic "orchid spiders" and mantids counterfeit flowers, less to evade enemies than to lure insects within reach.

DISGUISED AS HARMFUL

Natural selection has achieved one of the subtlest and most effective of all camouflages, the disguising of a harmless as a harmful species. Such a piece of bluff may be seen in the common hover fly, which many birds mistake at first glance for a wasp. As in most cases of this kind, the bluffer is less common than its model, otherwise the lesson of its warning colours would be wasted. The clear wing moths simulate bees and hornets, and the American viceroxy butterfly, itself tasteful to birds, imitates the nauseous monarch butterfly inhabiting the same regions.

Most remarkable of all these devices possibly are the pantomime dresses of certain plant bugs. The thorax is prolonged fore and aft so that it spreads like a roof over the insect's head and abdomen, and this roof is made to resemble



HAROLD BASTIN

NATURAL WEAPONS

A wasp wears a bright yellow jacket as a warning to other animals that if attacked it can give a good account of itself in spite of its smallness. The wasp's sting is composed of three distinct parts; a sheath, and inside it, two barbed needles. Above; left, the sheath; centre, one of the barbed needles; and right, the tip of a medium-sized sewing-needle. Right; The whole stinging apparatus, showing poison-bag at top and weapons at bottom.



ZEBRA'S DEFENCE

The zebra's stripes render it very conspicuous in captivity, but not in its natural surroundings, for stripes blend well with grass in strong sunlight.

all manner of objects, so saving the tasty and defenceless little bug beneath from foes. In one species the roof suggests a thorn, another a plant bur, or the distasteful cocoon of a moth. The climax is reached in a species whose roof actually mimics the head and body of an ant.

FACE-MAKING BLUFFS

These plant bugs are tiny objects and might pass unnoticed disguised or otherwise, but the make-up of the South American lantern flies is so large and glaring as to rout a foe by shock tactics. They have immense hollow structures projecting from the front of the head. Some species are larger than mice and so impossible to ignore. All are sufficiently arresting, but one has the hollow structure or lantern painted in bright colours so as to suggest a fearsomely grinning and glaring reptile of uncertain species but unquestionable savagery. No bird or monkey coming upon this suddenly stops to

investigate further. The face-making bluffs of puss and lobster moth caterpillars seem tame beside this insect's lantern, the precise import of which, save as an intimidating device, is unknown.

All these camouflages, in which a harmless animal mimics a harmful one, merely excite our interest, but one at least must be taken seriously.

DEADLY CORAL SNAKES

In the southern United States there are two, and in tropical South America twenty odd species of reptiles known as coral snakes. They almost invariably present red, yellow and black rings, arranged in varying order, and all the species are venomous, some fatally so. Wherever they occur there are also found harmless snakes so similarly marked as often to be mistaken for the deadly kinds.

In the harmful species the black rings are single and bordered with a pair of yellow rings, whilst in the innocuous kinds the yellow rings are single and bordered with a pair of black rings. Unfortunately the average person, even though aware of this, seldom remembers it at the right time, and the annual death rate due to coral snakes is considerable.

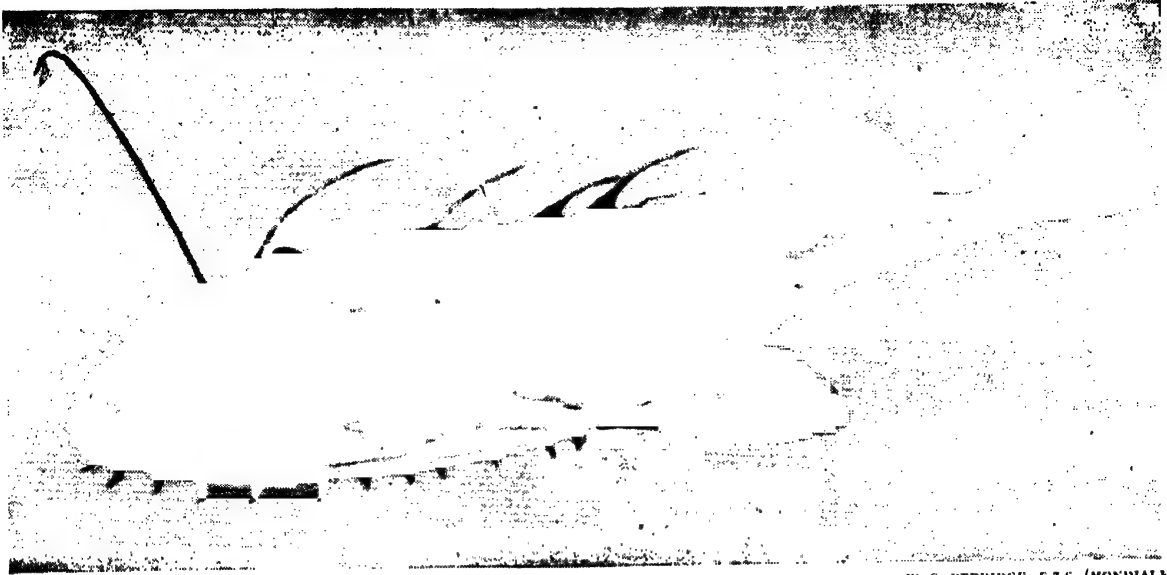
The most cunning camouflage may sometimes fail in its aim; discretion as to its use is half the game. Birds like the woodcock, and certain moths which mimic lichenous tree trunks, owe as much of their effective concealment to a wonderful capacity for keeping still as to their faithful imitation of surroundings. Movement on the animal's part would at once give the show away.

All tree bark imitators, like the various moths,



LIKE ONE OF THE GIANT DINOSAURS

Two male horned chameleons from Kenya. Most members of this sub-order of lizards lay eggs but the variety shown above produces its young alive. The chameleon's capacity for changing colour is often exaggerated.



W. S. HERRIDGE, F.Z.S. (MONDIAL)

WALKS AT THE BOTTOM OF THE SEA

The angler fish, or fishing frog, has more than one peculiarity. Out of its head grows a fishing "rod" whereby it attracts its prey; and it lives at the very bottom of the sea, walking there by means of its fins.

lichen geckos and the cobeco, a flying mammal, have wonderful powers of immobility. All the nightjars blend perfectly with moss-grown tree boles, and some, when alarmed, do not like the moths or lizards flatten themselves out, but sit bolt upright, in which pose they pass for stumps of branches or prominent knots.

In Central India is an expert race of thieves. Its members, if pursued in the open, run at

high speed and then suddenly "freeze" as game stalkers say, into some grotesque attitude, remaining thus in statuesque immobility until the pursuer has passed. The fugitive's naked, black and well oiled body passes muster as one of the twisted, fire-blackened tree stumps dotting the plain.

In like manner the little tent-peg squirrels of America and other animals elude pursuit by



WIDE WORLD

FISH THAT CARRIES ITS OWN FISHING-LINE

There are many fish that angle and that may therefore be described as living fish-traps, but few, if any, are so well provided with tackle as Gigantactis maeronema, whose line is four times as long as itself.



ANIMALS THAT HIDE BY DRESSING-UP

Left: A spider-crab "robing" itself in seaweeds. Right: A tropical "carrier-shell" sea-snail dressed in the dead shells of other molluscs. Spider-crabs sometimes shelter within the tentacles of sea-anemones.



WIDE WORLD

INNOCENT-LOOKING POISONER

The sea-anemone waves its poisonous but harmless-looking tentacles as it waits for its prey. Sea-anemones are akin to the corals, but do not form skeletons or produce colonies. Forty species are to be found in the waters surrounding Great Britain.

suddenly ceasing to run when the enemy is almost upon them. One of the greatest exponents of this art is the grotesque frilled lizard of Australia. Rising on its hind legs it runs at incredible speed and suddenly stops. The pursuer having run well past it, it at once heads the opposite way and makes good its escape.

SAVED BY FEIGNING DEATH

A form of camouflage is that in which an animal may imitate itself. The Indian sand boa and a few other snakes have the extremities so alike that it is not easy to say at a glance which end goes first. Sometimes the tail can be raised in a manner highly suggestive of a head about to strike, in which case the real head has a still better chance to obtain an early start in the eventuality of pursuit.

Feigning death is the animal's last line of defence. A tropic grasshopper thus saves itself from foes when passing through an intermediate stage between its larval form—when it mimics an ant—and its perfect state, when it resembles a growing leaf.

The past master in this art of immobility is the American hog-nosed snake, which not merely remains quiet, but goes limp, offering no



FISHES THAT IMITATE PLANTS

Certain fishes find it convenient to camouflage themselves by posing as plants. Left: Two slender pile fish. Centre: A tropical sea-horse. Right: A fish whose stripes enable it to blend with the weeds.

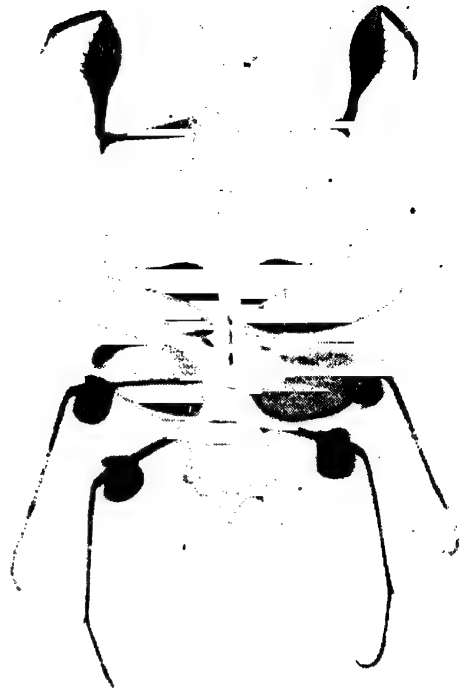
more objection to being handled than a piece of string.

Raymond Ditmars, the deservedly famous American student of reptiles, once thought to impress his native porters on an expedition with his occult powers. Taking up a lively hog-nosed snake, he apparently "killed" it with a few mesmeric passes, the snake of course automatically simulating death. Then, placing it on the ground, he made some more passes, when the snake, according to custom, having made sure it was no longer in danger, cautiously came to, and made off.

PLOT THAT REBOUNDED

The effect of this was unfortunate. The porters were not only impressed by their employer's psychic powers, but aghast at them, and yelling with terror, decamped into the gathering dusk, leaving the scientist alone with his baggage in a desolate and lawless region.

In our sentimental way we may be inclined to laugh at such an incident, forgetting that for



JIAROLD BASTIN

POSES AS A FLOWER

Gongylus gongyloides, an Indian member of the mantidae family, is coloured to resemble a flower.

long our forefathers believed in the most fantastic of travellers' tales. The mantids, for instance, were fortune-tellers. The appearance of one of these insects was invariably held to foretell famine or death, possibly both. As to the praying mantis, "so divine a creature" was this esteemed that if a child asked the way to a place where supplications are made to the gods, the insect "will stretch out her feet and show him the right way, and seldom or never miss. Walking softly, she retains her modesty and shows forth a kind of mature gravity."

DEATH-WATCH SUPERSTITION

Another superstition is in connection with the noise made by the death-watch. When heard it is held to portend bereavement, hence the name. Science, cold and calculating, reassures us. The listener is far more likely to lose money than a friend. The knocking is caused by the male beetle tapping its head on wood as a signal to his lady-love. The destruction caused by death-watch grubs burrowing in timber is incalculable. The insects did grievous harm to the roof of Westminster Hall.



WIDE WORLD

STICK INSECT

This insect, one of the phasmidae, is so long and thin that it looks like the branch on which it rests.



WHY THE LION HAS A MANE

Charles Darwin suggested that the lion's mane, like that of the baboon, serves as a shield to protect the wearer when fighting to the death with another of his kind for a mate. A device with a similar purpose is the goat's beard, which on occasion is a tuft of considerable length. Many extremely quarrelsome animals, however, are without face-trimmings of any kind.



COURTSHIP AS CONDUCTED BY THE ARTHROPODS

1. *The male fiddler crab and (2) a spider dance before their prospective partners.* 3. *The scorpion's parade; the male holds the female's claws and then proceeds to walk backwards a considerable distance.*

ANIMAL COURTSHIP

IN his play *You Never Can Tell*, Mr. Bernard Shaw makes two bright young people declaim in duet:

"In spring, and also in summer, autumn and winter, a young man's fancy lightly turns," etc.

Therein, neatly stated, lies one of the great fundamental differences between the courtship of man (and the man-like apes), and the courtship of almost every other kind of animal. With very few exceptions the beasts, birds and other creatures seek their mates at given seasons, but the higher primates are less chained by time.

Courtship in the lower animals is also more subject to a certain machine-made uniformity. Any fifty stags or crickets taken at random will go about their wooing with slight deviation from racial tradition, but even in our own conservative and custom-bound nation, courtship may ring millions of changes between the crudest horseplay and badinage on the one hand, and on the other the sonnets of a William Shakespeare.

Regarded simply as a spectacle animal courtship is of absorbing interest, and at times seems to offer curious parallels to that of human beings, although, as we shall see, such parallels are often more apparent than real. The urge on the part of the male to court, as distinguished from merely advertising his existence to the opposite sex, though becoming more and more obvious as we ascend the animal scale, is very unevenly distributed, and some creatures we might expect to court show no inclinations in this direction.

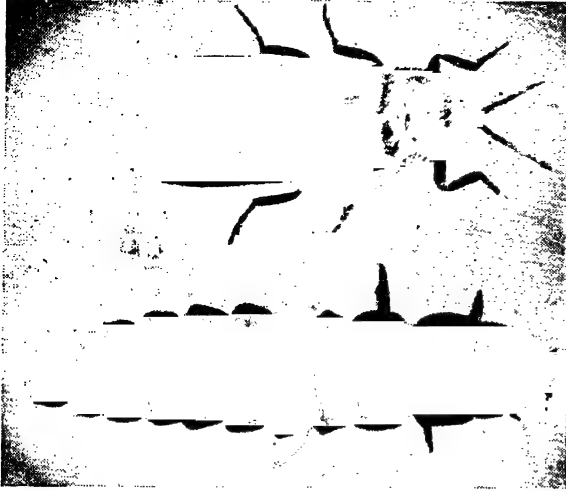
Courtship, where it exists, is nearly always conducted by the male, and polygamy is

probably more frequent than monogamy. Polyandry—the selection of many males by one female—is, as amongst human beings, of less frequent occurrence, though it undoubtedly occurs in some fishes and insects.

Perhaps the beginnings of courtship show themselves in certain marine bristle worms. The males at a certain time of year writhe convulsively in the coils of the females, thus inciting them to discharge their eggs, which the males promptly fertilize. Many molluscs, for example the common garden snail, are hermaphrodite, that is, they possess both male and female sex organs, yet these creatures show a dim foreshadowing of courtship, mutually exciting each other's reproductive instincts by plunging crystalline objects of appreciable size, known as "love darts," into each other's bodies.

Amongst the serried legions of the jointed animals, the crustaceans and insects, courtship becomes a more recognizable affair. Many of the crabs and lobsters show colourings and ornaments, or weapons that, as strictly male appurtenances, can mean but one thing. The craw-fish "grunts" by rubbing its feelers against its beak, and the male of the little snap lobster found on the southern coasts of England can snap the finger of its big right claw with a quite appreciable report—equal to that made by slapping the palm of one hand with two fingers of the other.

Still more picturesque is the wooing of the fiddler crab that swarms on every tropic and sub-tropic shore. The male has one claw double its body bulk, and most gorgeously coloured. This it flourishes before the dowdy little female with tireless persistency, until a satisfactory reply is vouchsafed.



HAROLD BASTIN

GLOW-WORM LOVE-MAKING

Male (top) and female, who lures the former by a light emitted from the extremity of her abdomen.

The scorpion has a bad name, but he shows a certain old-world elegance in affairs of the heart. The lady is approached and taken by both her claws, these being held in the larger pincers of the male, who then, walking backwards, conducts her on a love walk of considerable length.

In the minute "false" or "book" scorpion which infests linen and library shelves, we can see the reason for this strange conduct. The male, which is a miniature of the true tropic scorpion, without the sting-tipped tail, places the fertilizing agent in a minute crystalline cup, poised on a slender stalk. He has then

to find the lady and, having won her consent, he leads her by the claws until the cup is reached, and her eggs are fertilized. He may thus court half a dozen possibles before meeting with success.

Among the spiders we meet with courtships of a gruesome kind. There are species, it is true, in which both sexes live, for a time at least, in perfect harmony, but this is not the rule. Generally the male is to the female as might be a human dwarf to a cannibalistic giantess. He spends his wooing in alternately seeking to charm his lady with fantastic dances, or flying for his life. Sometimes he plays a sort of nightmare hide-and-seek amongst the lady's legs. One false step and her venomous jaws pierce him through and through.

HUSBAND AS WEDDING BREAKFAST

A dozen swains may thus pay for their temerity, and when at last one is accepted as a husband, as like as not he ends his career as a wedding breakfast for his bride.

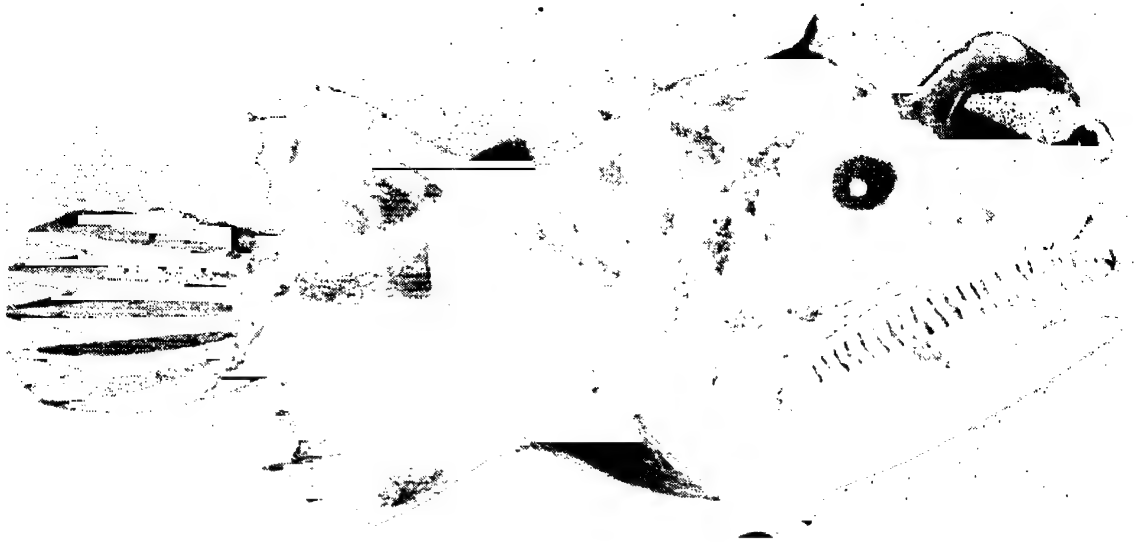
It is likely that the female spider's ferocity is prompted by a blind urge to fortify herself against the strain involved by egg production. Possibly this instinct also animates the female praying mantis, who sometimes devours her husband even whilst their union is being consummated.

More attractive are some of the devices adopted by the higher insects when seeking each other to fulfil their destinies. The female glow-worm lights her lamp in the damp hedge-row, and the less brilliant but winged males

**PURSUING NECTAR BEFORE A MATE**

HAROLD BASTIN

Smell aids moths in finding a mate. A long-tongued Mexican hawk-moth visiting a tobacco flower before going courting. It can extract nectar from the depth of a floral tube of even greater length.



WIDE WORLD

FISH THAT FEEDS ON ITS PARTNER

Photocorynus spiniceps is found in the Gulf of Mexico. The tiny male of this species attaches himself to the skin of the female and begins to feed upon the blood stream of his unfortunate partner.

fly to her casement with all speed. Many moths have an extraordinary sense of smell which aids in finding a mate, and the wonderful nuptial flights of the bees and other insects have excited man's attention from early times.

More in the nature of true courtship is the behaviour of the little carnivorous flies called empids. The males actually offer their desired partners gifts of food, such as other minute insects, enclosed in little quicksilver-like bubbles of fine silk or other secreted material, the lover flying here and there seeking a mate who shall appreciate his offering. In some species the gift takes quite an aesthetic form, being composed of a scrap of gaudy feather, a flower petal, or even part of the discarded wrapper from a sweet or cigarette packet.

FISH IN COURTING DRESS

There are some pretty, and some lurid, courtships to be seen amongst the fish. In those fishes which undeniably court, the male is always dressed for the part. The gallant not only exerts himself to the utmost to win his bride by blandishment, or, if need be, by force, but puts on a dress of magnificent though temporary finery. At such times all other males of his species and inoffensive strangers alike are hated rivals for his lady's favours.

Nobody, once having seen a stickleback in his courting dress—and mood, will easily forget

the sight. The robin stickleback comports himself with a dash and verve worthy of a creature many times his bulk. Members of the growing band of tropical aquarists will know the courtship of the little Siamese fighting fish, who outshines even the robin stickleback in inspired fury and devotion. The fish glows with burning tints, as though illumined from within, and after a whirlwind courtship, tightly embraces the adored with his entire body.

PUGNACIOUS AT PAIRING TIME

The little goby waxes pugnacious at pairing time, and so also does the salmon, the male displaying an extraordinary hook-like development of the jaw at this season. The English dragonet shows the male at courting time as a fish equalling in bizarre form and vivid colouring any denizen of tropic seas.

The displays of some male fishes, and others of the lower vertebrates, though unquestionably passionate, are still in the nature of automatic reflexes. It would be a fatal error to humanize them, and to read into them anything approaching the loves of our own species. Once the fish courtier has won his bride, he is done with her. When, as sometimes happens, the male takes charge of the eggs, the mother may even prove a cannibalistic foe, to be driven off at all costs.

The amphibians are nearly related to the fishes, but the two main groups into which amphibians are divided—the frogs, toads, etc., and the newts, are as strikingly contrasted in courtship as in outward form. In the former the males simply advertise their presence by the well-known croaking chorus, and having seized the first available mate, courtship, such as it is, terminates.

POSTURINGS AND CONTORTIONS

With the newts matters are much more elaborate. The male extrudes the sperms in a little balloon-shaped capsule, which the female must take in her two hands, press to her feet, and with these place the package in her oviduct. But it is not enough just to put the sperm case within sight of a female. To rouse her interest the male assumes a glaring dress of black spots on a chestnut and crimson ground with a saw-toothed crest running from nape to tail tip, and thus attired engages in extravagant posturings and contortions, until his offering meets with acceptance.

By all the laws of logic, reptiles should show

an advance upon fishes in their love-making. It may be that they do, but up to the present so little attention has been given by scientists to the matter that no such assumption is justified. Turtles and terrapins often congregate in vast numbers to deposit their eggs in one specified area, but whether these assemblies involve any form of courtship we do not know. Many snakes gather at certain seasons to form huge inextricable tangles of both sexes.

MASS MEETINGS OF CROCODILES

Mass meetings of crocodiles are reported, and the males of the big monitor lizards are known to duel on their hind legs where the possession of a mate is in question. Probably the cumbersome and bizarre horns worn by some male chameleons are in the nature of adornments. Considering how these reptiles even when roused live in slow motion, they could scarcely be considered as weapons.

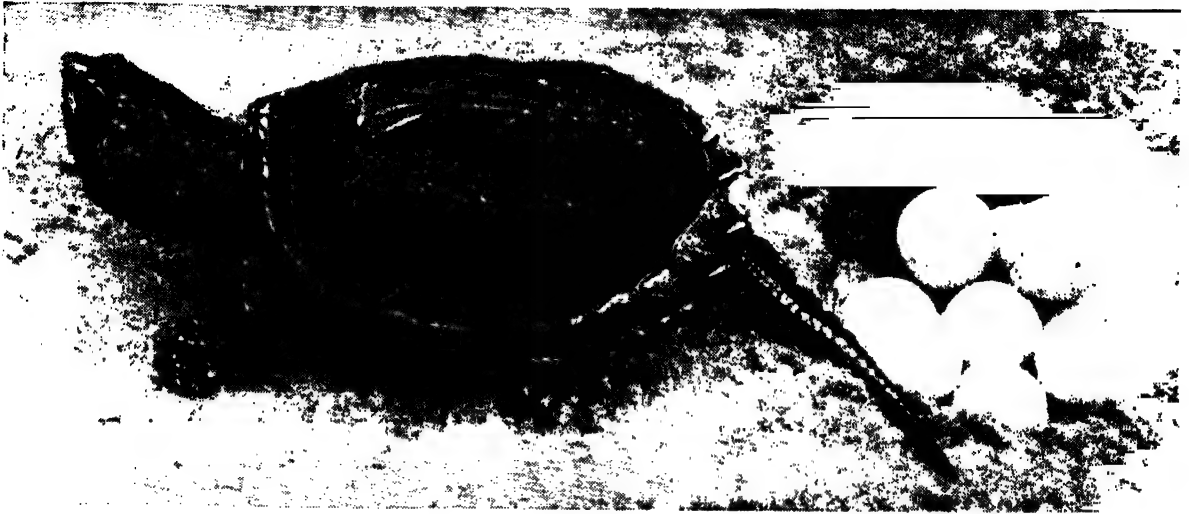
In the British Isles at least, no single phase of animal life in the entire Arcadian calendar has enlisted such general interest, sympathy and



K. STULCKEN (MONDIALE)

SHEDDING AN OLD SKIN FOR A NEW ONE

Female striped newt after sloughing skin, which can be seen hanging on the branch of the water-weed. When courting the male assumes a glaring dress with a saw-toothed crest running from nape to tail tip.



DORIAN LEIGH

TURTLES PREFER TO LAY EGGS IN COMPANY

Turtles often congregate in large numbers to deposit their eggs. This specimen carefully scanned the near horizon, covered her round white eggs, and crawled back to the swamp whence she had come.

imagination the courtship of the birds. To most of us springtime is epitomized in the sparrows' noisy chatter, the cuckoo's note, the song of the mounting lark and the sweet warbling of the thrush and blackbird.

CEREMONIAL AND SONG

Song ranks but as an item in feathered love-making. Bird courtship implies also elaborate dress, and even more elaborate ceremonial. Though song and ceremonial may be as automatic as the sprouting of fine feathers, their wonder does not lessen when we consider the crude workmanship of the bird brain compared with that of the much higher but less aesthetically inspired mammals.

Bird song is often very obviously a love song, but is not always so. Recent observers have established that it is frequently a defiant declaiming of territorial rights, a challenge to rival cocks to enter the charmed circle of the nesting site, if they dare. This is very apparent in the case of England's common warblers the males of which arrive from winter quarters on the continent of Europe in advance of the females. When the hens arrive, song largely gives place to an invitation to collaborate in house building.

This is a device exhibited by many male birds. When a desired partner is found, she is approached with scraps of moss, leaves or twigs, and coaxed into partnership. Amongst some penguins, such as the Adélie of South Georgia, in the South Atlantic, stones make the nest,

and selected pebbles are solemnly dropped by Benedict before his Beatrice.

As in other creatures love-making amongst the birds is largely controlled by physiological factors, and particularly in the female. Often the eggs forming within the hen bird must reach a certain stage of development before they are fit for fertilization, and when this point is arrived at, further efforts on the part of the male are required to inflame her to the pitch of actually mating.

THE ETERNAL TRIANGLE

Among the warblers, song is later augmented by pretty dances and posturing, spreading of wings and tail, and other antics played from the vantage point of some convenient twig, within full sight of the hen, and calculated to show the suitor at his best.

A strange feature in the courtship of many birds is the segregation of the males at breeding time. This gathering is no light-hearted bachelors' club, but a sort of mass meeting of male mannequins, each straining every faculty in a frenzy of display. To this assembly the females come in due course, walk round it, and eventually make their choice.

An instance of this seen in England is that of the ruff's "dance hall," usually a piece of waste ground rising from out an expanse of marsh. Here the males, in their wonderful ruffles, which look like judges' wigs, pirouette and twirl dizzily for hours on end. Anon come the sober-looking reeves (hen birds) to look for

mates. When a cock is obviously selected, he changes his dance for an elaborate abasement, spreading his wings flat upon the ground, and placing his beak point down to the soil. Where the eternal triangle occurs, the two males concerned engage in savage conflict, their ruffles serving as shields against each other's stabbing beaks.

Even more striking is the dance hall of the prairie hen, one of the grouse tribe. Some grouse, like the red grouse, are monogamous,



OLIVER G. PIKE (MONDIALE)

RELATED TO THE SNIPE

The female phalarope does the courting. Her male partner takes care of the eggs when they arrive.

and courtship at its most exciting resolves itself into no more than a duel between two cocks. But in the American prairie hen, as in the handsome black-game, courtship is a matter for a mass meeting.

From March to early May the prairie grouse assemble at some open space—its open quality largely the outcome of previous meetings which have stamped the ground clear. The cocks make a bold show, with horn-like tufts of feathers erect on either side of the head, and large bare sacks of skin puffed up to the size of golf balls. These augment the bird's voice, and help to produce a startling booming sound, which can be heard a mile or two distant. The cocks also loudly cackle, clash their wings, and leap high into the air. The ground becomes strewn with feathers, and the turmoil continues for an hour or more after sunrise, when suddenly it stops, the rivals feed peacefully side by side,

and quiet reigns until another dawn breaks, when again they enter the lists.

Those extraordinary members of the crow family, the birds of paradise, outshine all other birds as male mannequins, but appear to have little idea of duelling. So elaborate are the plumes of many that duelling would probably be scarcely practicable. The males of each of the few score known species display distinctive crests, shields, or other adornments of dazzling metallic hues and almost incredible designs. Some when displaying are only recognizable as birds at all by their beaks and feet, and even these can be hidden by the voluminous finery.

MALE MANNEQUINS

A selection of typical paradise-crow gallants are shown in the picture. The Count Raggi, for example, has elaborate tail plumes, as also have many other kinds. The greater and lesser birds of paradise have waterfall-like cascades of orange plumes falling from what approximate to our armpits. The twelve-wired paradise-crow has exaggerated head ornaments, and the superb an immense distensible shield of burnished green and copper springing from its breast.

These dazzling inhabitants of the New Guinea jungle are precluded from such violent exercise as the grouse indulge in, but they still make display in a marked manner. The Prince Rudolf bird, for example, is one of the upside down school, as is also the superb paradise-crow. The Prince Rudolf bird completely inverts itself, spreads its wings, and trembles violently from head to foot. The first specimen ever brought to a zoo so horrified its keepers by these acrobatics that they thought the bird was in a fit, and treated it to a quite unwanted dose of physic.

BIRDS BUILD DANCE HALLS

Courtship perhaps reaches the summit of æsthetic refinement in another group of Australasian birds, the bower builders, which, like the birds of paradise, are members of the crow family. With few exceptions, the male bower birds are as unadorned and even dowdy as the inconspicuous hens of the paradise-crows. But they compensate for any lack of personal charm in the amazing dance halls, or assembly rooms, which they construct. So huge are some of these structures, that early travellers in Australia mistook them for aboriginal cradles.



BIRD OF PARADISE GALLANTS AND ARGUS PHEASANT

Top (left): Lesser superb bird of paradise, great bird of paradise, and (below) Prince Rudolf bird of paradise. On right, the same birds "in display" when courting. A typical hen is also shown. At bottom, Argus pheasant. When courting, the male in the background raises his wings to form a fan.



OLIVER G. PIKE (MONDIAL)

SEXES ALMOST IDENTICAL IN APPEARANCE

The hen bird of the great crested grebe meets her lover half-way when he is courting. In appearance the sexes are almost identical. They are more at home in water than on land.

Each species builds in characteristic style, using special materials, and putting them together with conservative ritual. No other animal structures, not even the most elaborate erections of beavers or social insects can approach in artistic discernment and downright workmanship these avian retreats secreted in the fastnesses of the Australian bush. Both sexes may collaborate in making the bower, which, whilst it is undoubtedly inspired by the pairing instinct, and is used as a love bower, may also apparently satisfy some æsthetic or social craving long after the fires of passion have burned low.

DECORATED WITH FLOWERS

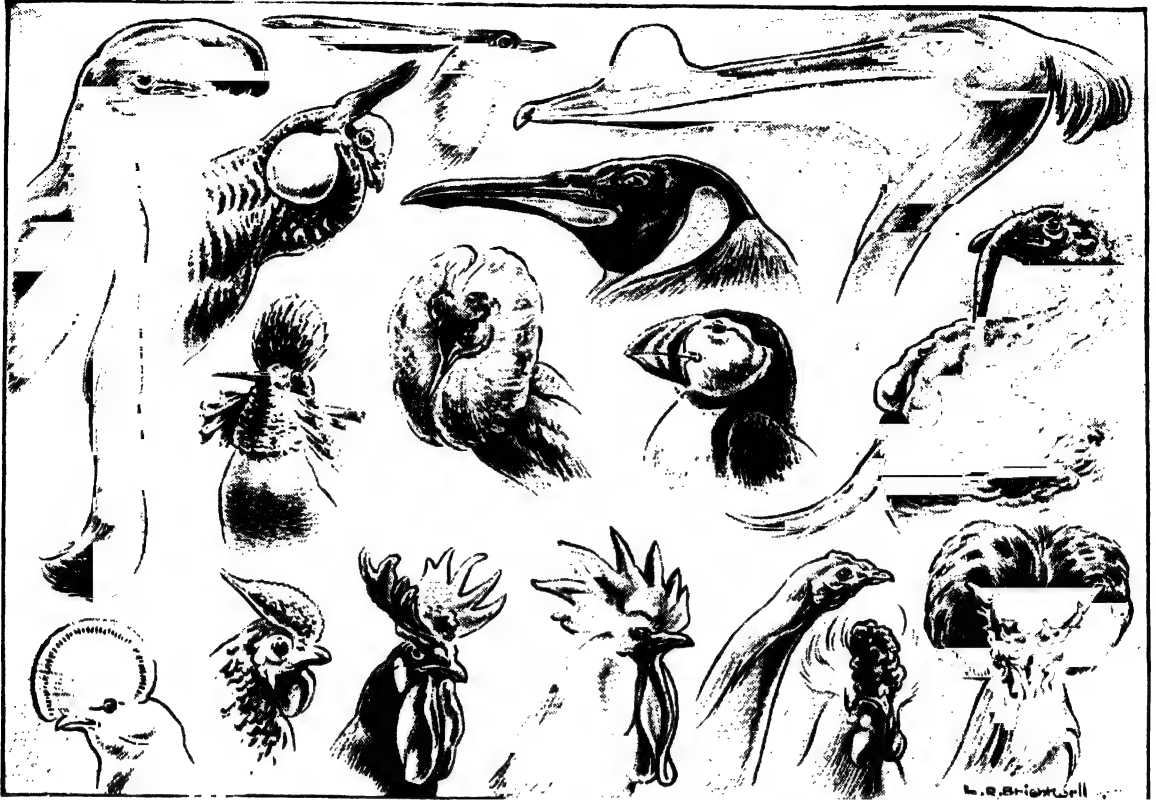
New Guinea's gardener bower bird heads the list in artistic refinement. It builds out of twigs a two-feet-high hut at the base of a tree, crowning the roof with moss. In front of this structure is a lawn of moss, which is decorated with gay flowers and berries, the embellishments being renewed as often as they fade. Zoo captives invariably use what ornaments they can come by—glass marbles, new pennies, silver paper, and even bus tickets.

The golden bower bird is a mere amateur at decoration, but what it lacks in refinement it makes up for in size, for it constructs a big straggling dance hall fourteen feet long by six feet wide. Sometimes it builds on a more modest plan and crowds four or five huts into a space only ten feet square. Some kinds pile the hut up against a tree trunk until it reaches a quite imposing height, and often show a marked predilection for some special colour.

DANCE OF THE PHEASANTS

Perhaps the palm should go to the satin bower bird, which actually plasters the inside of its wooden hut with a sort of gesso or distemper made from chewed wood pulp. The bird has an unusual fondness for anything blue, a colour which matches its prominent eyes.

The bower birds are adepts in all kinds of dainty bobbings and curtsyings, but in this regard they are easily outshone by the pheasants. Each species of pheasant has its special dance, the out-standing performer of the clan being the Argus pheasant of Malaya. Like the so-called lyre pheasant of New Guinea, this bird shows wonderful skill in steering its enormous tail feathers through dense underbush.



ATTRACTIONS DISPLAYED BY MALE BIRDS WHEN COURTING

Top: Umbrella bird, prairie grouse, jay shrike, king penguin, pelican. 2nd row: Humming bird, ruff, puffin, turkey. 3rd row: Cock of the rock; domestic fowls—Hamburg, flower bird, Langshan, game, silky, Houdan.

In courting the male raises his wings to form a fan little less impressive than the peacock's famous tail coverts. The hundreds of eye spots on the wings face the hen in an unwinking stare, whilst their wearer peeps coyly between them to observe the effect he is making on the lady.

The largely automatic nature of bird courtship was strikingly evinced by a captive Argus pheasant mated to a hen of a related species. She failed apparently to understand his advances, and the bird, after exhausting himself in fruitless endeavours to please her, finally courted a metal feeding pan.

HEN MAKES ADVANCES

Courtship, usually the male prerogative, finds a reversal in the phalarope, a genus of wading and swimming birds related to the snipe. Larger and handsomer than the cocks, the hens do the courting, afterwards leaving the care of the eggs to their male partners. Among other orders the hen bird will meet her lover half-way. This is very noticeable in the almost identically dressed sexes of the great crested

grebe and also in the fulmar petrel, both sexes of this bird charming each other by amorously displaying the blue interiors of their mouths.

ACCESSORIES TO COURTING

Feathers by no means exhaust the catalogue of bird finery. The combs and wattles of farmyard cocks and turkeys at once come to mind, and these but touch the fringe of masculine magnificence. The love-sick puffin puts on a brightly striped over-beak, suggesting the nose of Mr. Punch, the king penguin wears salmon-coloured shields on his lower beak, and the male white pelican mounts upon his upper bill a big horny comb-like erection as big as the palm of one's hand. All these fripperies are shed when courting is over, and litter the mating grounds as thickly as autumn leaves in a lane.

Air-sacs, as seen in the prairie hen, are converted to erotic uses by many other birds. The frigate, or man-o'-war bird of the tropics, distends a huge scarlet bladder on its neck and a similar organ quite surrounds the



W. S. BERRIDGE, F.Z.S. (MONDIALE)

HELMETED BIRD

The cassowary, like the emu and the ostrich, has an air-sac which adds volume to his voice.

unlovely neck of the Indian adjutant stork. In the ostrich, emu and cassowary this air-sac helps to give the voice volume. Livingstone recalls how he once mistook the voice of a love-sick ostrich for the roar of a lion.

In these big ungainly birds the dance is an important feature of courtship, and such high kicks are indulged in that the performer is sometimes thrown upon his back.

CASTANETS OF THE STORKS

The greater wing power of the cranes and storks improves their foot play, and the storks in particular, masters of the *pas seul*, accompany themselves by a deafening castanet solo, rendered by clattering the two portions of the horn-covered beak together with incredible violence and rapidity.

Contradictorily enough the tender passion finds less poetic expression amongst the undeniably more highly-constituted mammals. In some the expressions of emotion may even, by the standards of civilization, seem actively repellent, though such expressions are often not without very obvious human parallels.

Voice plays a big part in mammalian love-making, the roof-concert of the cats bearing painful testimony to the fact. Many creatures, like the deer and porcupine, are virtually mute

save at mating time, and in some creatures the normal vocal organs are enormously augmented by special devices. A male orang-utan, for example, wears a huge pouch upon its breast which gives great resonance to its voice.

All other animal voices, however, even the lion's roar, are as nothing compared with that of the Brazilian howler monkey. Though no larger than a cat it is undoubtedly the most vocal of all animals in relation to size. In both sexes, but especially in the male, the bones of the tongue are converted into a thin hollow shell of bone which may be as big as a man's fist. Scores of travellers have described the terrific sounds given out by this amplifier.

SCENT IN COURTSHIP

Scent is not without its erotic significance in our own species. Much more so does it play a part in animal courtships. Scent glands may serve as weapons, as do those of the skunk, or to blaze a trail, as for instance those in the hoofs of sheep and antelopes, but in many animals are found special scent glands which only make themselves manifest at pairing time.

Such glands are to be found above the eye in bull elephants, and behind the head in bull camels, and at certain seasons exude a thick,



LESLIE R. JONES (WIDE WORLD)

ADJUTANT STORK

A huge distensible bladder with a love-making significance adorns the ugly neck of the long-legged and ungainly adjutant stork.



OLIVER G. PIKE (MONDIALE)

LOVE DISCLOSED BY STRIPED BEAKS

Both male and female puffins have large sharp-pointed bills. The love-sick male puts on a brightly striped over-beak which is shed when courting is over.

powerfully odorous fluid. Even stranger is the "bloody sweat" of the hippopotamus, often responsible for the curious pinkish tint enlivening the normal drab colouring of the skin. The amorous bull hippopotamus exudes in great quantities this secretion, which dries to form a crystalline substance of unknown properties.

It is not so long ago since British manhood advertised itself in flowing locks, voluminous beards, pendant side-whiskers, and ferocious moustaches. Several nations still favour

such adornments, and the animal world has never discarded them. In the wild at least, where brawn is at a premium, they stamp the male.

Darwin propounded the theory that such embellishments as the lion's and baboon's mane, or the bristling beards that cover some goats' frontal portions from chin to breast, were natural shields to protect the wearers when two males fought to the death for the love of a lady. But as we shall see when we

**HORNED AND PLUMED FOR MATING**

The male white pelican grows a large horny comb-like protuberance, as big as the palm of one's hand, on the upper bill during the mating season, but it drops off when courting days are over.



ANCIENT AND MODERN

Above: The hippopotamus as it really looks at close quarters. Below: As a medieval artist conceived it in a natural history book of the year 1491.

glance at animals in their relation to man, some of the most pugnacious creatures are entirely innocent of face trimmings.

DESIGNED TO CAPTURE THE EYE

The general consensus of opinion today regards such hairiness as male insignia designed to capture the eye of beauty quite as much as to withstand a foe. No other explanation can be offered regarding the wonderful moustaches of some male marmosets, or the bushy beards of certain little South American monkeys that

seldom use their teeth on anything but nuts. The bare patches of vivid colour often seen on various monkeys undoubtedly tend to the same end.

As with some birds, many mammals congregate together in great numbers at courting time, and then only. Kipling has painted a vivid and accurate picture of this in his fine story *The White Seal*, which tells of how at rutting time the bull seals gather by hundreds on some secluded beach, and there fight out their differences, tearing each other's hides to ribbons in the process.

As we ascend the animal scale we find a marked tendency to make love, as does man, in secret. Having its well-springs in physiological processes, it is yet conducted as much with the brain as with the body. Personality tells, more and more. The finding and winning of a mate involves ever increasing subtleties denied the lower forms of life.

MYSTERY OF THE APES

We still know little or nothing of the home-life mysteries and intimacies of our next of kin, the man-like apes, but they possibly present more features in common with human behaviour than at the moment meets the eye. An interesting example was offered when the Zoological Society of London was seeking a mate for the female chimpanzee who later became the



MONDIALE

SCENT GLANDS OF THE BEAVER

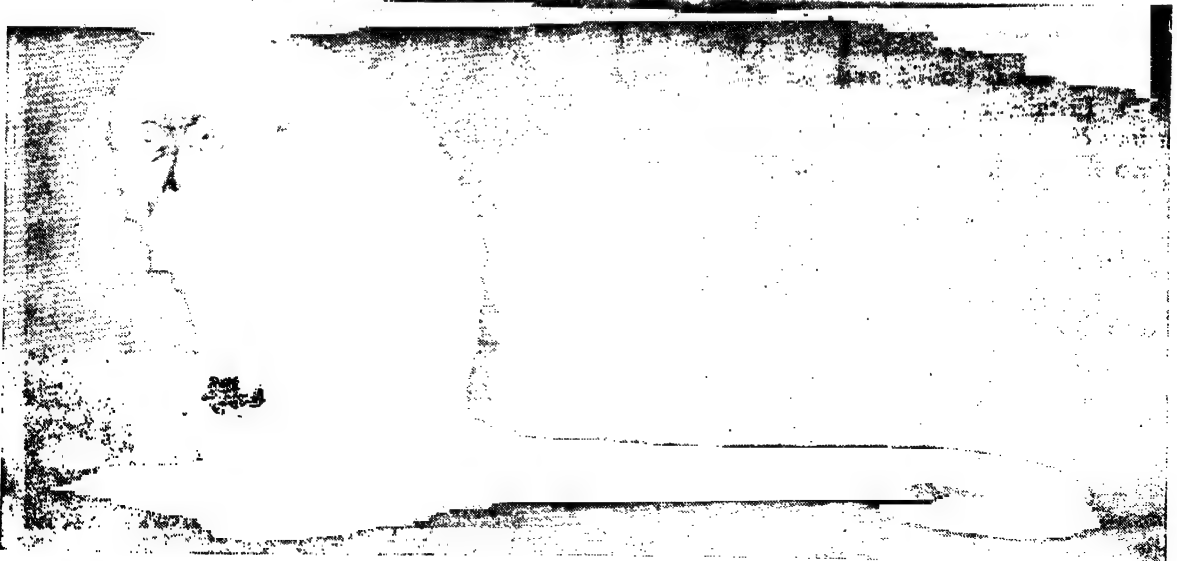
Many animals have special scent glands which only make themselves manifest at pairing time.



ORANG-UTANS IN A TREE-TOP

MARTIN JOHNSON (WIDE WORLD)

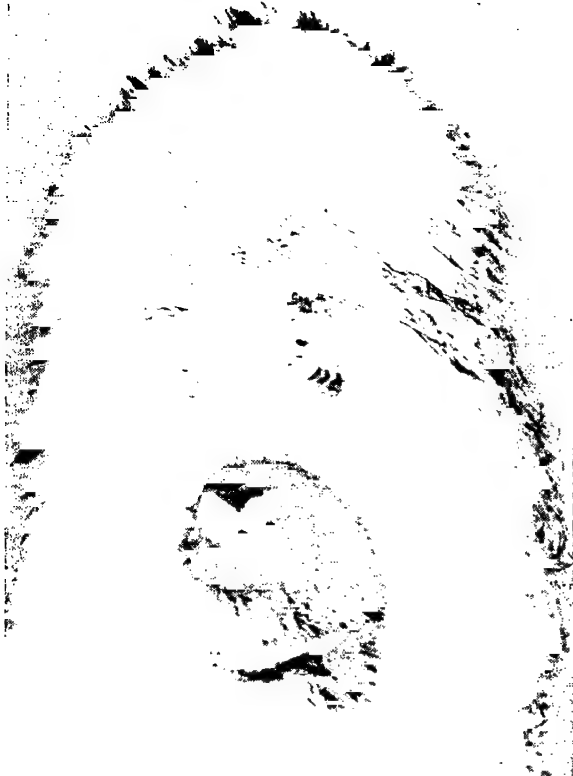
The courtship of man-like apes has many features in common with that of man. Most animals will mate with any member of the other sex, but not so the chimpanzees, who choose their partners with care.



NOISIEST OF ALL THE MONKEYS

W. S. BERRIDGE, F.Z.S. (MONDIALE)

Voice plays a large part in the love-making of mammals. The Brazilian howler monkey, seen above, has a louder voice than any other animal in relation to size.



WIDE WORLD

MAN OF THE WOODS

The orang-utan lives in Borneo and Sumatra. The males have a huge throat-sac on throat and chest.

mother of Jubilee, the first chimpanzee ever born within the metropolis.

For some time prior to the mother's successful mating, suitors had been sought throughout the many zoos, public and private, both in Great Britain and abroad, and also from various circuses and pet keepers. Boo-boo, the eventual mother of Jubilee, would have none of them. Finally, a middle-aged, but in all ways quite undistinguished male chimpanzee, Koko, was loaned from the Clifton Zoo, at Bristol.

CHARM IN A CHIMPANZEE

Without any apparent efforts on his part, Koko, the inferior of many of the rejected, at once walked into favour. At the time of writing he is the only father chimpanzee in Great Britain, with several children to his name, scattered up and down the country's zoos. Here then is a clear instance of that indefinable quality comprised in the terms charm and personality, manifesting itself in an animal whose possession of such many people would deny. Immeasurably less pleasing to the

eye than the eagle, courting in the empyrean blue, or the peacock mincing on the lawn, Koko still knows far more about that force which, the poets tell us, makes the world go round.

BEHAVIOUR IN NATIVE HAUNTS

Chimpanzees in their native haunts would appear to have anything but a docile nature. There have been notable well-behaved individuals in the various zoological gardens of the world, and the fact that scores of thousands of persons have been photographed with young chimpanzees in Pets' Corner at the London Zoo is proof of the docility of the animal before it reaches maturity. Cases have been known in West Africa of these apes killing and devouring native children. It was for this reason that when a conference on the fauna and flora of Africa took place in the House of Lords in 1933, the chimpanzee, at first included in the list of animals recommended for the maximum of protection, was afforded less immunity.



DOG-FACED MONKEYS

On the posteriors of the baboons are patches of hardened skin which in some species are brightly coloured.



ARTHUR BROOK (MONDIAL)

ONE OF A PHEASANT'S FAMILY OF TWELVE

Most birds try to conceal their nests, and the female is often drably coloured. The pheasant builds its home on the ground, and is partial to a place where there are dead leaves.

HOW ANIMALS MAKE A HOME

COURTSHIP is the natural precursor of marriage, the making of a home and the bringing up of a family. To Nature's creatures of the wild the family is everything, the home only of importance in so far as it ministers to the family's needs and ensures the future of the race. Man stands alone in taking pride in the permanence of the structure he calls home, and even his pride in this is of comparatively recent development. Temples and tombs in plenty survive as evidence of the culture of ancient Egypt, but not a single private dwelling.

History shows that the status of the home has been in exact ratio to national advancement. We should therefore not expect to find pride in the home by any means a universal attribute of the human race. Morocco cheerfully avails itself of wireless and other refinements of civilization, but in matters domestic the people stand where they did in Bible times.

All over the world one meets tribes that have not changed their mode of living since first the white man stumbled upon them. Of none is this more true than of the numerous nomadic races.

Sometimes nomadism is the result of choice, sometimes of necessity. The latter applies to the Hausas of the Sudan, for ever wandering from one exhausted water supply to a fresh centre of sustenance; to the shiftless American

Indian perpetually in search of game; and to certain coastal Esquimos, kept on the move by a climate that cramps and circumscribes all their activities.

It is not surprising to find that man's nearest relatives are similarly given to a nomadic existence. None of the apes or monkeys has any fixed abode. They favour certain areas, but never pitch camp in the same place twice. The man-like apes, it is true, build each night raft-like structures of twigs and branches well above ground, there to sleep immune from foes, but morning finds the place left far behind them and utterly forgotten. In the case of the gorilla, the head of the family or little clan sleeps at the tree foot. The purely arboreal orang-utan makes a temporary home even for an afternoon's siesta.

There is every reason for the unstable habits of these forest dwellers. Living in a land of plenty, with a climate inductive to anything but work, they have become care-free lotus eaters, much as have many humans in similar circumstances.

It is likely that the conception of a home, that is, of a structure made by an animal from substances outside itself, for its protection and possibly the shelter of a family, began far down the animal scale. It was a movable residence, as easily carried as an Indian's wigwam. The first such structures were made by the minute builders of the chalk hills, and the creatures

whose shells now form the ooze covering vast areas of the sea bed. These infinitesimally small organisms made dwellings of mineral substances gathered from the surrounding water. Such homes are often of exquisite and most complex design and infinite variety.

WORMS IN TOWERS

A step higher in the scale we meet with homes the construction of which can be followed with comparative ease by means of a simple microscope. Ponds and rivers teem with a race of creatures which for want of a better designation have been classed as worms, and are popularly known as rotifers, or wheel animalcula, so called because hair-fringed structures on the creatures' heads maintain a rapid oscillating movement which produces the illusion of rotating wheels.

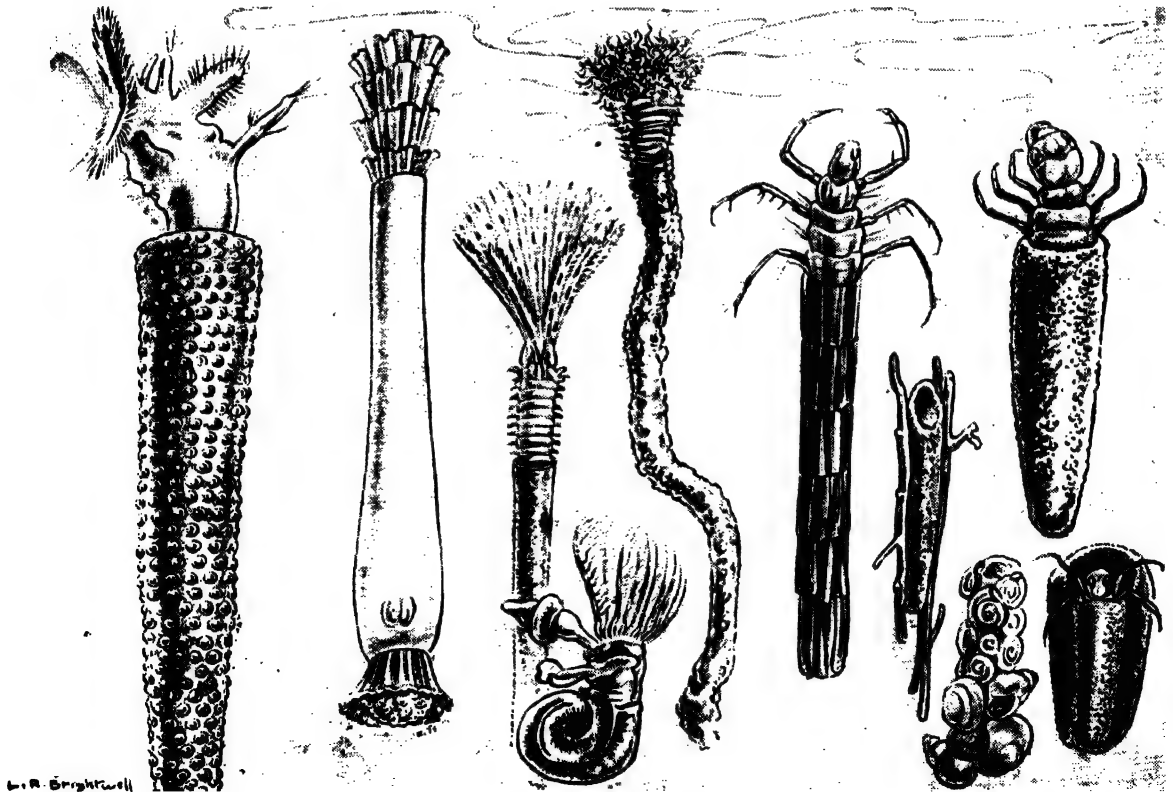
Often these wheels are used only to aid respiration and to sweep eatables into the mouth, but in some species of fixed abode the wheels actually assist in the formation of circular bricks of mineral matter. These are placed side by side in rings piled one above

another, the whole is cemented together and so gradually forms a tube or tower in which the animal rests secure, at least from foes of its own size.

The brickmaker is one of the larger of the rotifers, a clan whose members vary from one-twentieth to one-five-hundredth of an inch in length. Few unfortunately have popular names, but all who have read Charles Kingsley's *Water Babies* will remember "Floscularia," the beast which so excited the wonder of the little chimney sweep turned water sprite.

BRICKLAYERS OF THE SHORE

Among the higher worms tube-building becomes very elaborate. Hundreds of kinds of home-making worms infest the seas, and the shores of the British Isles abound in examples. Everyone knows the tubes of the peacock worm that protrude from the sand at low tide, suggesting stubble stalks after harvest. Just as familiar are the little limy worm tubes encrusting every blade of weed or dead shell; and the honeycomb worm that on some sandy shores



TUBE BUILDERS

Among the higher worms tube-building is very elaborate. From left to right: A rotifer, highly magnified, watering-pot shell; various species of marine worms; caddis fly larvæ and cases.



STRANGE HOMES OF CADDIS WORMS

Cases made by caddis worms, the larvæ of the caddis fly. The cases are formed of various materials, including freshwater shells, sand, dead leaves and scraps of driftwood.

raises what look like miniature coral reefs, strong enough to bear a stranded boat.

An ordinary pocket lens shows that these sand tubes are made by superimposing grains of sand one upon another in circular tiers, like bricks in a tower or factory chimney. Special structures situated on the worm's head collect the sand particles and pass them along to the bricklaying organs at a terrific speed.

MOLLUSCAN ARCHITECTURE

The coiled tubes often seen encrusting weeds are built of lime, plastered whilst soft and mixed with a cement secreted by the worm upon the rim of its tube, the dwelling thus steadily increasing with the creature's bulk.

Here we see the beginnings of that wonderful architecture perfected by sixty thousand species of molluscs living today, and formerly practised

by many more species now extinct. Special glands secrete colouring matter, and this, combined with the most varied architecture, results in those lovely forms so noticeable on a seaside ramble.

BUILDERS OF MIGHTY SHELLS

Since lime is the basis of all molluscan shells, land and freshwater species never produce such massive dwellings as do marine molluscs. Among the latter, pride of place goes to the three-feet-long shells of the giant clam of the Barrier Reef off the east coast of Australia, and the two-feet-long whelk of South Carolina, U.S.A., the world's largest snail.

Lime similarly forms the home of the so-called coral insects, the tiny sea anemone-like creatures that build huge stony reefs throughout tropic seas. For some reason coral animals, unlike molluscs, seem never to have colonized cold



INSECT TUNNELLER

The mole cricket has developed shovel-shaped fore limbs not unlike those of higher burrowers.

waters to any extent. England boasts a single native species in the cup coral found fairly abundantly off deep water on the south-west coast of Devonshire.

All the univalves—that is one-piece shelled molluscs like the whelk and garden snail—are active, highly mobile animals. In them we see beginnings, not merely of home building, but of a homing instinct. Marked limpets have been found to return repeatedly to the same pitch, and apparently use it so persistently that the rock is often worn away by friction until a shallow depression is formed.

SNAILS COME BACK

Mark the shell of a garden snail—say with one's initials—and fling the snail over the garden wall; it will be found back in its old home twelve hours later. Though it be flung over half a dozen gardens—or as far as one's arm can carry—the result will be the same. Like the proverbial cat, the snail comes back.

If the shell suffers damage at the end of one of these aerial journeys the snail is equal to the occasion. It pours out an extra quantity of cement and repairs the damage, such repairs being obvious enough but still extremely serviceable.

All molluscan shells consist of several layers, and where the layers vary in colour, as in the tropic helmet shells, we get the materials for cameo cutting. The smooth iridescent mother-of-pearl layer lining many shells, both univalve and bivalve, is the basis of all commercial pearls, natural or cultured. Any foreign body irritating the animal is covered over with mother-of-pearl to prevent friction, much as one muffles an obstinate corn with a piece of lamb's wool. The big Roman snail of England's chalk hills makes a home within a home

when winter comes by tunnelling into the ground, much as the piddock clam burrows into limestone.

In the jointed animals, house building develops in a dozen directions. Many soft-bodied defenceless larvæ, like those of the common caddis flies, emulate the tube-building worms and shell-making molluscs, though in much more clumsy fashion. Each species of caddis worm larva has its particular style of architecture. Some cover their nakedness with sticks placed endwise or in concentric layers, others use shells, stones and sand. The mineralogists amongst these insects, if dragged from their tubes and put in an aquarium well supplied with glass beads, produce very startling and picturesque residences.

SHIELD AND CRADLE

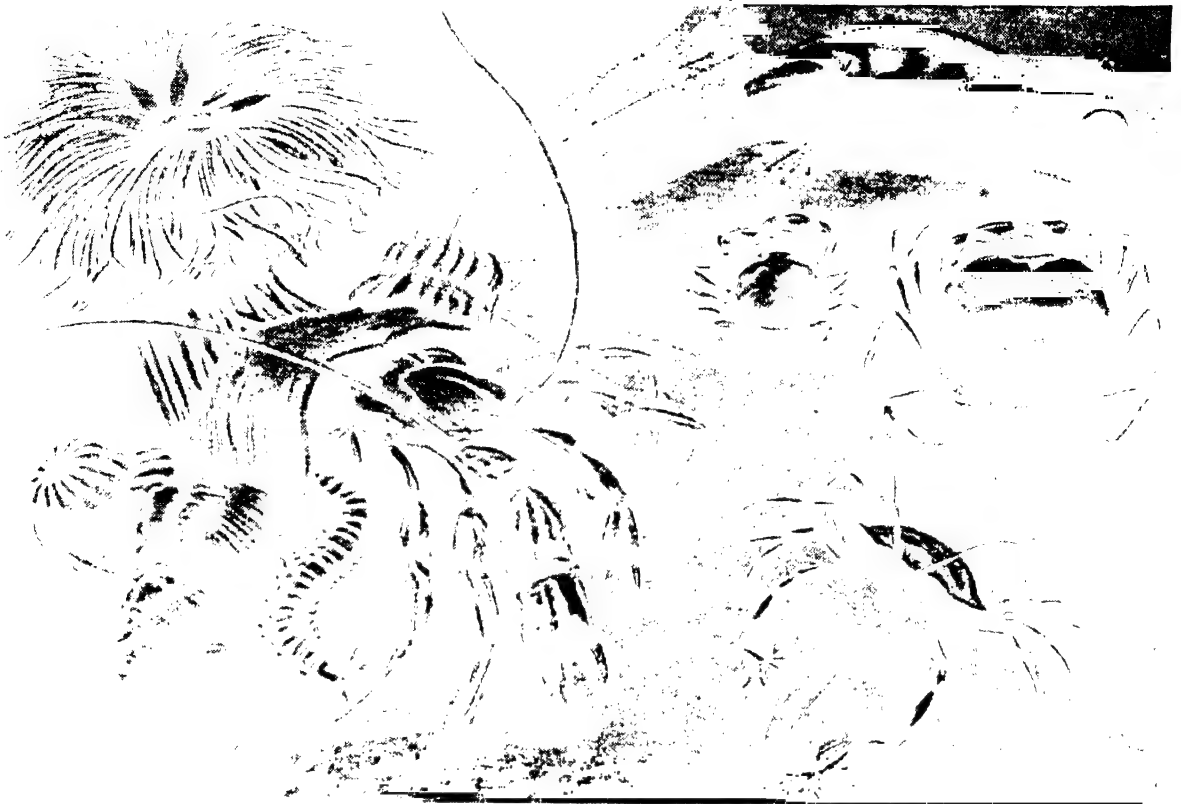
The caddis worm's home is at once a present shield against foes and a safe cradle in which it may tide over that hazardous period spent as a helpless chrysalis, awaiting the great change into the perfect caddis fly.

Every conceivable material has been pressed into service by insect ingenuity. The bees make wax from flower extracts, the wasps paper and cardboard from chewed wood, the tropical termites raise earth hillocks almost defying pick and shovel, and large enough to support big trees. Silk forms the temporary abodes of innumerable spiders and insect larvæ; tunnelling has been perfected by all kinds of spiders, insects and crustacea. Some tunnellers, like the burrowing prawns and the mole cricket, have developed shovel-shaped fore limbs that bear a striking resemblance to those of much higher burrowing animals



IN A BORROWED HOME

A tiny crab that has taken up its quarters in the accommodating shell of a sea-mussel.



MESSMATES OF THE OCEAN FLOOR

1. *Hermit crab with anemones and a worm which share the crab's food.* 2. *Pea crabs, male (M) and female (F), which shelter in the mussel. Crabs to scale, and enlarged.* 3. *A tropical crab that employs anemones to catch food for it.*

such as the ant bear and the various moles.

As we ascend the animal scale, home-making increases in complexity, and reaches its grand climax in the birds, though always and only with a family in sight. If we except the bower birds, no animal delights in a residence for its own sake. The beautiful and intricate structures made by social wasps are as purely utilitarian as the makeshift residences of hermit crabs.

FORTRESSES OF THE CRUSTACEANS

Those diverting crustaceans, so abundant in all seas, show a wonderful adaptability in the choice of borrowed homes. Most tuck their defenceless rear portions into solid univalve shells (a whelk's, for example), but these unyielding castles need to be constantly changed to allow for the tenant's growth. When, as sometimes happens, a big anemone attaches itself to the residence, it dissolves the shell away, and encloses the hermit crab in an easy-fitting protective tunic of unlimited stretching capacity.

Some species of hermit deliberately dress themselves in anemones, and one kind finds an equally accommodating fortress by tucking itself into the elastic tissues of a sponge.

FISH AS ARCHITECTS

Home-making amongst animals is usually so inextricably part and parcel of child welfare that here we will give our attention mainly to the mere materials and their utilization in accommodating a family.

Many fishes are painstaking architects, and often both sexes work together for the general weal. Wrasses thus make big ball-shaped nests of weed; salmon and trout clear spaces in the stream bed with their tails; and the lampreys, male and female, laboriously construct a nursery by removing heavy stones one by one with their suction mouths. Sometimes both householders and a few neighbours join forces where a particularly heavy stone is concerned. The American bowfins make a nursery clearing in a reed bed several yards in extent.



KINGFISHER'S RETREAT

Legend had it that the nests of kingfishers floated on water. They are in a hole in a bank.

In Great Britain at least the frog will never earn a reputation for tender motherhood. She light-heartedly dumps some hundreds of eggs in the nearest water and there the matter ends so far as she is concerned. Sometimes all goes well, but sometimes the water supply fights a losing match against a hot sun, and the eggs are dried up before they can hatch. Even the toad, though trekking at infinite pains year after year to the same ancestral pond, thinks no more of its rosary-like strings of eggs once they are deposited.

TREE FROG ENGINEERS

But there are frogs and frogs, and some members of this numerous tribe vie with the birds in care of their young. In Japan the male and female of a certain tree frog work together to make a snug underground nest for their spawn conveniently near to a well-filled irrigation ditch. They dig a tunnel from nest to ditch, and when at last the tadpoles emerge, they have but to wriggle down the sloping runway, always constructed at an angle, to launch themselves for life.

In Paraguay a wonderful little frog known

as the wallunnkukk joins forces with his wife to wrap the eggs between two leaves overhanging a pool, so that when they hatch the tadpoles are only a step from the water which is to be their domain. Even this is outdone by a Brazilian tree frog which makes a veritable swimming pool for its infants by fashioning a basin-shaped structure of mud on the sides of a forest pool. The mud walls are neatly patted into position by the parents, and when the tadpoles wriggle clear of their gelatinous egg cases they are safe from hungry fish and water beetles.

SHARING A HOME

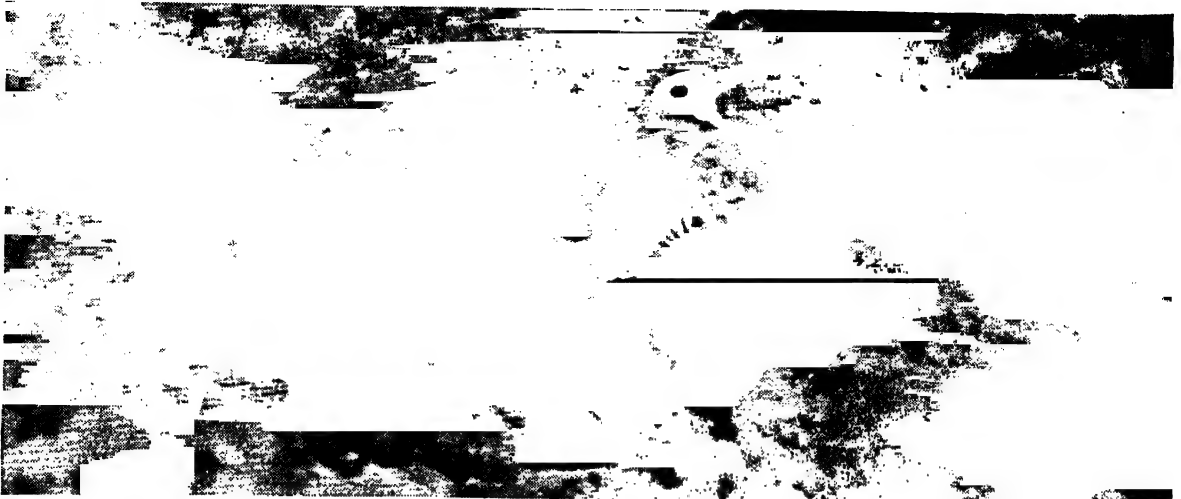
Judged by human ideals, reptiles are as unsatisfactory in their home interests as in their love making. A few are indifferent burrowers, the most thorough in this direction being the New Zealand tuatera, a lizard-like creature, last survivor of a now extinct group.

It makes a burrow some two feet long in soft earth, digging with its strong claws, and invariably laying its dozen or so eggs on the right-hand side. The left side is often allocated to a small species of petrel, bird and reptile living on good terms. For a reptile, the tuatera is quite a home lover, since it remains in residence throughout the whole of the incubatory period, a matter of thirteen months.



BUILDERS OF MOSSY NESTS

Humming birds prefer to hover while feeding, when their wings move at nearly sixty beats a second.



DR. GRAF ZEDTWITZ (MONDIALE)

LITTLE ATTEMPT AT HOME-MAKING

A few wisps of grass or an accumulation of offal and fish scales form the nest of the gull. Elaborate architecture would be wasted on the wind-swept, spray-drenched edge of a cliff.

Remarkable as is the diversity of birds' nests, certain general principles seem to govern their construction. In almost all instances the builders seem to play for concealment, and there is amongst the more intelligent birds a marked tendency to build elaborate nests.

Some ostriches dump their eggs in the sand like lizards. At the opposite end of the scale we have the crow-like bower birds with their wonderful assembly rooms, and that still nearer relative of the crows, the common magpie, which not only builds a capacious nest strong enough to withstand many winters, but even provides it with a roof.

FAMILY IN A BOTTLE

All conceivable materials may be pressed into service, and the strangest sites are chosen. A blackbird has been known to build a nest entirely of watch-springs, a tom-tit to bring up a large and clamorous family in a ginger beer bottle, an old boot, or a discarded kettle. Only where weather or other conditions would make nesting a thankless task is there little attempt at home-making. The gulls and razorbills on the wind-swept, spray-drenched cliff edge would be wasting energy on elaborate architecture, and so a few wisps of grass at most, or an accumulation of offal and fish scales makes cradle enough for their hardy broods.

Burrowing birds there are in plenty, as witness the sheld duck and the puffin. The Argentine oven birds excel swallows as plasterers. They build relatively immense

structures, very like old-fashioned earth ovens, placed in the most exposed situations, as on the top of a post or rock, where the sun bakes the material iron hard, and makes the oven a difficult object to break open.

IMMUNE FROM ENEMIES

The hornbills of Africa and Asia use clay to wall up the hen bird after she has clambered into a hollow tree trunk by way of a convenient hole. The orifice is reduced by means of clay until only a space big enough for the passage of food is left. Here the willing prisoner remains, fed by her mate and immune from snakes and monkeys until the eggs are hatched and the fledgelings big enough to take care of themselves. The so-called edible swallow of China, lacking clay, supplies its own cement in the form of a glutinous saliva, making with this and its own feathers a basin-like cradle on the face of a cliff.

As one might expect, home-making reaches a high pitch of perfection among arboreal birds, which must often use ingenuity not only in finding nesting materials but also in securely fastening the home amid the wind-rocked foliage. A triumph in this direction is achieved by the little Indian tailor bird, a species of warbler, which actually sews pendant leaves together with fibres, and in the cup so formed makes a nest proper of hair, down, lichens and grasses.

An eye for colour as well as for quality of nesting materials is very apparent amongst such perching birds as orioles. During the



WIDE WORLD

WALLED UP BY HER MATE

The hornbills of Africa and Asia use clay to wall up the hen bird when a hole has been found in a tree trunk. The opening is made smaller by means of clay until only a space big enough for the passage of food is left. Here the hen remains until the eggs are hatched and the birds ready to fly.

past ten years a wonderful series of experiments have been carried out at the famous Three Brooks Wild Life Sanctuary, near Roxburgh, Connecticut, U.S.A. The chief subjects of experiment have been orioles, birds which normally tend to build with strips of vegetable fibre, bark, scraps of vine, and so on.

BIRDS THAT LIKE BLUE

During the first eight years of offering the birds unusual materials, such as cotton, horse-hair, and afterwards, coloured wools, the birds were chary of such innovations. But at last they took so kindly to the suggestions that they used nothing else, and produced nests of immense size and astonishing design. Late in the series of experiments other birds were apparently so struck by the rainbow-hued edifices of the orioles that they followed suit.

So here in this sanctuary are orioles with football-sized nests of flaring mauve, white and orange yarn; waxwings with scarlet nurseries; and king birds bringing up their babies amongst festoons of white cloth. Some birds acquired such a liking for blue that after introducing a few blue ribands into the general colour scheme of their nests, they elected in succeeding seasons to build with nothing else. Some of these nests glowed like orchids.

INGENIOUS NEST BUILDING

One might continue almost indefinitely listing the varieties of perching birds' nests, and the devices to make them and their fragile contents enemy proof. The helplessness of the young is the greatest of all incentives to ingenious nest building. Even when, as in the case of the common sparrow, several broods may be produced in a year, the family is always smaller than in ground-building types, which

**NESTS FASHIONED OF LEAVES**

Left: The nest of a Brazilian frog. Centre: The Indian tailor bird, which sews pendant leaves together with fibres, and in them builds a nest. Right: A tropical ant that uses its larvæ as shuttles.



WIDE WORLD

STORKS DO NOT LIKE CHANGING HOUSE

- 1 *A stork returning to its nest, which is usually on the top of a building. Built of sticks, the bird uses the same home every year and adds a few more twigs and branches to the structure.*

produce self-helpful young not so much in need of protection.

Some humming birds bind their mossy nests together with spiders' silk and hang them at the extreme tip of a leaf. The honey eaters hang their soup-tureen-shaped nests by both ends from a branch too slender to bear even a snake. The weaver birds and others find safety in numbers and build huge communal nests accommodating dozens of families, which unite to mob a common foe or give each other warning when danger threatens.

PROOF AGAINST NEST RAIDERS

The desert wrens of Arizona build homes in the fleshy stems of the big candelabra cacti, nightmare plants so densely clothed with needle-like spines as to daunt the hardest bird-nester.

The hoatzin of Brazil always builds its nest upon a tree branch overhanging a stream. There is a reason for this. The fledgeling hoatzin can, almost from the first, scramble about the branches with beak, feet and wing fingers. But in Brazil danger in the form of

monkeys or tree snakes may threaten from above. If this happens the baby hoatzin cheerfully takes a header into the water and strikes out with all four limbs together, using a stroke very like the crawl.

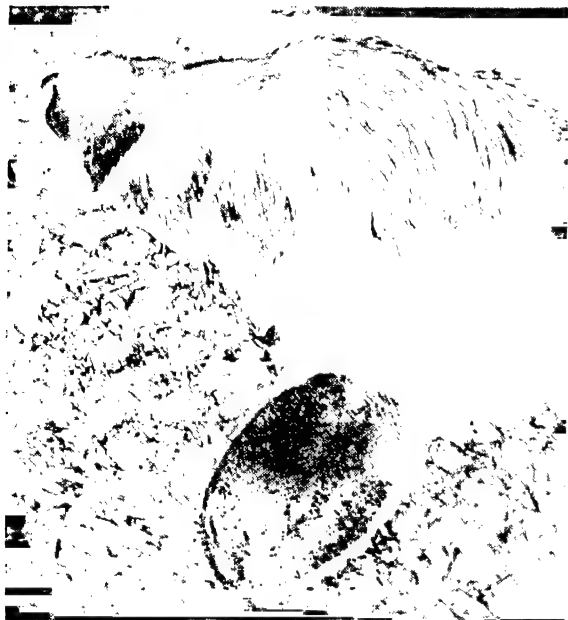
NEST TWENTY FEET HIGH

The remarkable homing instinct, so apparent in many migratory birds, often leads birds to repair an old nest and use it season after season. Mr. Cherry Kearton has recorded an instance of ospreys or fish hawks visiting the same nest for so many years in succession that the pile of sticks and fish offal of which it was composed eventually reached a height of twenty feet. It might have towered even beyond this but that it became lop-sided and collapsed in a gale.

Compared with these wonderful structures of the feathered world, mammalian homes are somewhat disappointing. The carnivora are chiefly content to select a cave or a clearing in dense scrub for the shelter of their young. A few of the smaller species show ingenuity in the art of burrowing, notably the moles,

ant bears, and the rodents. The badger has little to learn in this regard. Some years ago a road collapsed as the result of two badgers driving their earth beneath it. At one point they had dug down through the solid chalk, full of large and sharp flints, to a depth of eighteen feet.

Small wonder that the fox is often glad to avail himself of this ready-made accommodation, the badger seeming to offer little resentment. Many burrowers line their innermost



ANIMAL ENGINEER

The true beaver is the largest European aquatic rodent. His scaly tail has almost become a fin.

sleeping chambers with dried grass, even when no family is in evidence, and show a certain crude sense of hygiene. At the Whipsnade quarters of the London Zoological Society the prairie marmots can be seen every autumn drying freshly-cut hay for their winter quarters, and they periodically take advantage of a fine day to give this rough upholstery an airing, or even renew it altogether when it has become fouled past endurance.

Many squirrels and a few of the smaller lemurs make nests almost worthy of a bird's best efforts. The squirrel shows considerable forethought in providing two exits, with a view to effecting an escape at short notice.

The beaver stands in a class by itself among mammals as a home-maker, and has given rise to innumerable Indian legends as well as

highly-coloured but inaccurate accounts in early natural history books.

The beaver forms pools in which to place its lodge and food stores, but not from any real appreciation of water finding its own level. It simply digs and digs until the stream it is seeking to divert at last runs the way it is required to go.

BEARS THAT NEVER COME

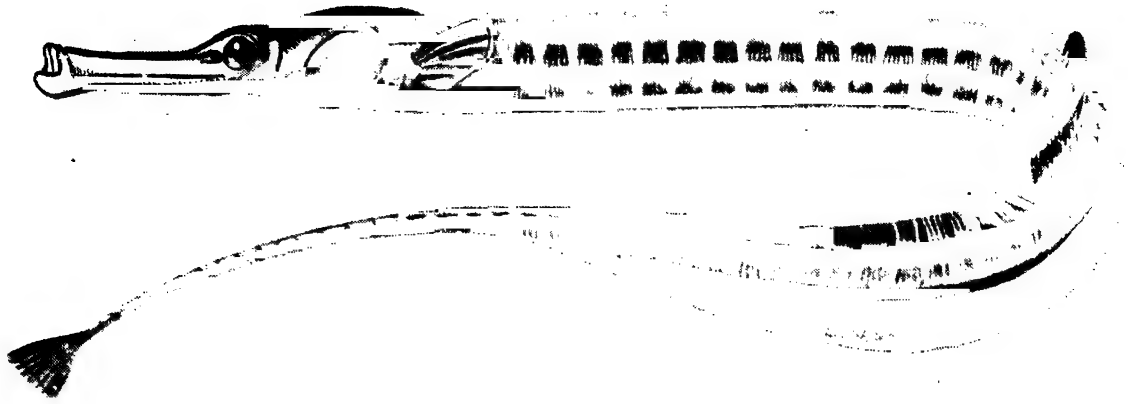
Innumerable instances can be quoted of the beaver being hoist with its own petard as a result of not fully appreciating the forces it is seeking to harness. It is true that it often fells a tree so that it falls conveniently for bark stripping, but the tree sometimes jams among other trees, and there are instances of beavers being crushed through the fall of a tree.

Beavers have lived in a wild "natural" sanctuary at Horsham, in Sussex, for forty years or so, but they still keep on the alert for the bear and wolverine that never come, and feverishly provide bark against each winter despite ample rations of all the foods they like best. Neither will storms nor floods induce them to forsake their water-logged lodges for comfortable sleeping boxes. Their natural sleeping chambers are dug deep in the lake's bank, just above water level, with two exits, one above, the other below water level.

PLUGGED WITH CLAY

One of the most ingenious of mammalian homes is that made by the aquatic duck mole of Australia, a beast which after all has more in common with birds than any other mammal. Its burrow shows more ingenuity than that of even a mole, for on retiring to rest it plugs the way in with a wad of stiff clay. Apart from the ingenious spring door of the tropical trapdoor spider, the average animal can think of no better device for excluding unwelcome callers than to fill the entrance to its home with a spine-covered head or an exaggerated claw.

As for the bears that fail to eventuate, the black variety is particularly partial to the neighbourhood of a fallen tree. With its powerful claws it digs a hole sufficiently large to accommodate its bulky body, the trunk forming a kind of roof which is also a measure of protection against enemies. If the timber is massive the animal will hunt for a hollow tree and make itself as comfortable as a night watchman in his hut. The female polar bear usually chooses a natural ice cave in which to rear her family.



"NURSING" FATHER OF THE PIPE FISH FAMILY

Two flaps of skin on the under-surface of the male pipe fish fold one upon the other to form a pouch. In this the female deposits the eggs. The pipe fish is a very attenuated version of the famous sea horse.

BRINGING UP A FAMILY

THE quality of mother love or parental devotion in animals is decided largely by the number of progeny. Anything like individual attention, or indeed concern of any kind, would scarcely be practicable in animals like the ling or the turtle, which count their families in multitudes. In the case of a communal insect, the mother, or queen, is a mere egg-laying machine, and her brood, numerous as the sands of the sea shore, is tended by a horde of neutral nurses, as passionless and mechanical in their ministrations as the robot-like El-women of Scandinavian legend.

Parental devotion might be assumed to reach a high standard in many mammals, birds, and fishes, if judged only by the pains taken to make a nursery, some examples of which have been outlined in the previous section. Devotion to young, however, is largely a matter of intelligence, and some of the world's most devoted animal mothers are creatures having little need or inclination to found an elaborate home.

Apes and monkeys, the most feckless and indifferent of home-makers, are not far behind our own species as nurses. Long after the infant has been weaned they test every mouthful of food before allowing the baby to swallow it. They also show wonderful patience in supervising baby's early attempts at climbing, lending their tails for the purpose. Not that foolish indulgence is the rule in monkey circles.

A somewhat spartan discipline goes hand in hand with maternal tenderness, and where correction is deemed necessary the firm right hand is never spared. Bats similarly nurse their small families, and so do most of the rodents and the carnivora.

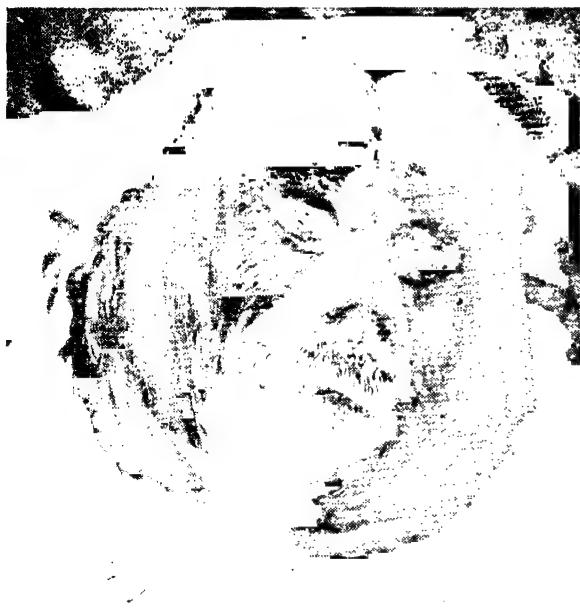
All who have seen it must have been impressed by the sight of a lioness inculcating the first principles of hunting by letting her cubs worry her tail tip. In the wild such lessons could be carried further by the bringing home of some small animal sufficiently maimed to give the family practice in the use of their weapons. Similar behaviour marks the family life of most birds of prey.

Large numbers of young mammals and birds pass through a rigorous schooling. The goat's kids find their mountain legs by staggering up and down the recumbent mother; the sea lion launches its youngster on the water, often when the little one is very loath to take the first plunge. Recent observers have given graphic accounts of how the golden eagle induces its young first to trust themselves to their wings, even dropping pieces of food in mid air, but within distance of the nest upon the cliff face, and so tempting the youngster to leap into the void.

Whilst many birds' nests become incredibly foul as the droppings of the brood accumulate, sea birds and some birds of prey remove such waste matters or coax the infants to deposit them hygienically over the edge of the nest,

thus showing apparently some grasp of the rudiments of sanitation.

In our own species parental solicitude denied its natural outlets may find a substitute in adoption, or even in the keeping of pets. A similar state of affairs obtains with many of the higher animals. Recent observations of the gull have shown how blindly the bird will brood on almost anything once it has conceived the desire to sit. It will accept a ball, or even a tin box, if robbed of its eggs. We



WIDE WORLD

NIGHT MONKEY OF GUIANA

Long after the infant monkey has been weaned its mother tests every mouthful of food.

all know the readiness with which the domestic hen will accept a china substitute. The changeling which the cuckoo so successfully foists upon its dupes is another classical example that is worthy of note.

In the bird market at Singapore, Mr. Walter Goodfellow, the famous collector, saw huge consignments of the popular Java sparrow cooped together in one cage. With each batch of some fifty nestlings there would be one or two adults, and these, when food was placed in the cage, literally wore themselves out dispensing it to the young with such devotion that the supply was exhausted long before they gave a thought to their own needs. In the Antarctic, an orphaned penguin chick is often literally killed by kindness by the joint efforts

of a host of self-appointed foster parents, and an orphaned egg is invariably smashed between the would-be mothers, each determined to sit upon it.

From time to time the illustrated press brings to our notice a cat brooding ducklings, or a ferret mothering rabbits. In menageries it is very customary to hand a batch of lion cubs which have been born to a sickly or indifferent mother to the care of some matronly retriever or collie. The cubs seldom fail to thrive under such circumstances.

SHEEPDOG AS LION'S FOSTER MOTHER

An extraordinary case occurred many years ago at the Sydney Zoo when a lion cub was allowed to remain with its foster mother, a mongrel sheepdog, until it had reached full lion's estate. So complete was the dominance of its nurse that the lion, which could have effaced her with one tap from its paw, had eventually to be removed to ensure that it got its proper amount of food.

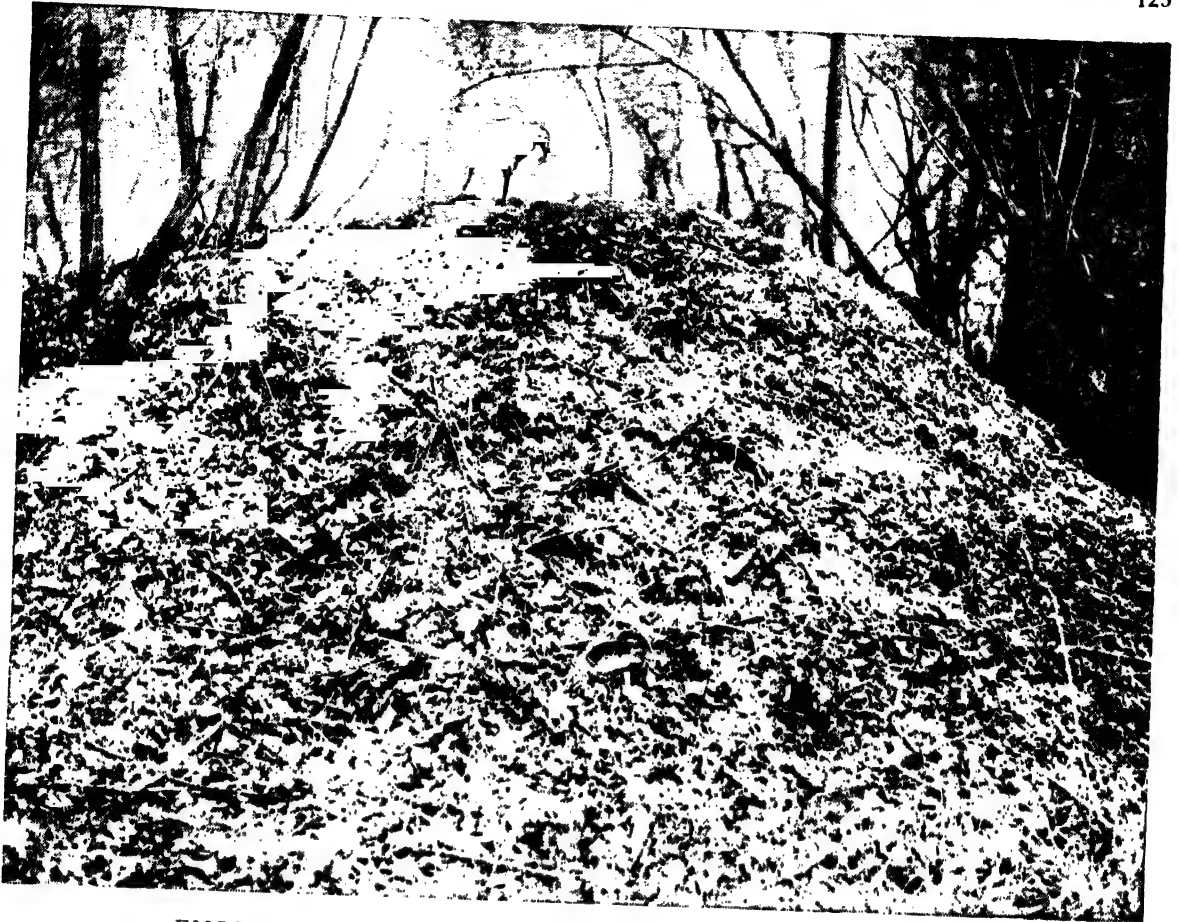
Records of the Anthropological Society in India show that the story of Romulus and Remus being suckled by a wolf was undoubtedly based upon actual fact, though the wolf-reared children of reality grow up into anything but woodland godlings. Such children indeed seldom survive for long when attempts are made at their reclamation to ordinary ways of life.

"NURSING" FATHERS

In glancing at the various ways in which animals make a home, it was noticed that the work was generally shared by both parents, but that responsibility for the family usually devolved upon the female. There are many cases in which the natural order is reversed. For reasons which are often obscure, responsibility for the future of the race, apart from the actual deposition of the eggs, is left to the male. The "nursing" father is an established institution in many widely different classes of animals.

Among mammals it is customary for father to bethink himself of bachelor joys as soon as the family appears. Unless he volunteers to walk out, the mother, knowing his irritable temperament, as often as not deserts him for the time being, in order to bring forth and nurse her young in peace.

Only one mammal apparently reverses this order. The male marmoset would seem to be



ENORMOUS NEST OF THE AUSTRALIAN BRUSH TURKEY

FOX

The one or more hens of a brush turkey household usually rest or hunt for food, whilst the cock raises a mound of impressive size. The hen or hens deposit eggs within the mound.

the partner of a frivolous wife, for he at once holds the baby as soon as it is born, handing it over to his partner only when its nourishment makes this imperative. Her duties having been very perfunctorily performed, she returns with all speed to more congenial employments.

MALE MARMOSET'S CHARGE

The father's job meantime is no sine cure. Laden like a miniature Sinbad, he toils about the tree branches bearing his precious burden, until its bulk and exuberant vitality must make its final relinquishment a very real relief.

A whole group of nursing fathers is provided by the ostrich tribe, nursery duties lying with the cock bird in the ostriches proper, the rheas, emus, cassowaries, kiwis and tinamous. The male ostrich may be called upon to take charge of as many as thirty eggs, and the emu nearly a score.

The South American cock ostrich or rhea appears to have its limits of endurance and willingness to be imposed upon. The ladies queue up to the saucer-shaped hollow in the sand which serves as a nest, and proceed to dump their eggs under the watchful eye of the nurse-to-be. When he decides that the nest is filled to capacity he intimates as much by kicking and pecking the still laden hens until they wander away disconsolate. Later the plain is strewn with orphaned eggs, and there they stay until cleared away by wild dogs or wandering gauchos.

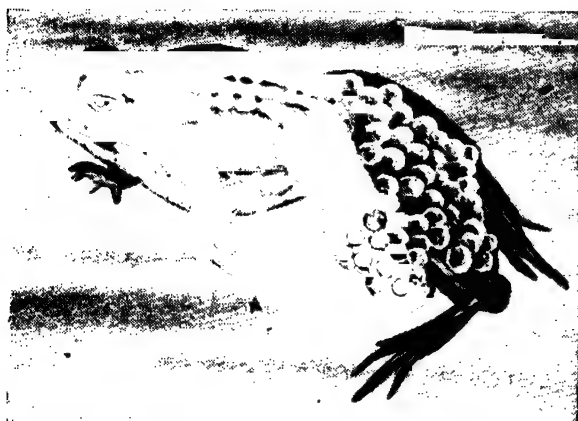
INCUBATED BY THE SUN

The ostrich's wings, so impracticable for flight, are of great use when it comes to covering a score or so of eggs each equal in size to two dozen of the domestic fowl's. The cock bird subsides amongst his furbelows, like a seventeenth-century lady amongst her hooped

skirts, and so stays for about forty days, the hens only under the rarest circumstances offering relief. In exceptionally hot localities the cock merely covers the eggs with sand, and, mounting guard over them, leaves the actual work of incubation to the sun.

With the evolutionary chain in mind, the ostrich's way of sometimes leaving eggs to hatch by the heat of the sun recalls the methods employed by most living reptiles, the last representatives of the forerunners of the birds. This reptilian trait finds its highest expression amongst birds in the remarkable brush turkeys of Australia.

These birds are not unlike the faro-yard



HAROLD BASTIN

MALE MIDWIFE TOAD

It gathers the eggs, which are laid in long strings, and attends to them until the tadpoles arrive.

gobbler in general appearance, particularly the cock birds, who display resplendent wattles (fleshy lobes under the throat) in the nesting season. The one or more hens of a brush turkey household usually rest or hunt for food, whilst the cock by kicking leaves and rubbish backwards with his enormous feet, raises a mound of impressive size. Where several birds combine to make a communal mound, and build upon the same site several years in succession, it may measure one hundred and fifty feet in circumference, and be higher than a man. The efforts of a single bird will sometimes amount to as much as five tons of rubbish worked up into a compact pile. The ground round such an edifice looks as though it had been scoured with a vacuum cleaner.

Within this mound the hen or hens deposit eggs, usually arranged in concentric tiers. There they remain for several weeks, the cock

from time to time testing the mound's temperature by thrusting in his bare neck, and adding or removing debris as he deems advisable. The infant brush turkeys are extraordinarily precocious even for the young of ground-dwelling birds. They scramble their way to freedom, and are able to scratch for a living and even to use their wings as soon as they gain the light.

This reptilian mode of incubation brings its own difficulties. The snug mound commends itself to certain huge lizards known as monitors, and they hasten to deposit their own eggs in the nest so conveniently provided for them. The lizard eggs hatch quicker than do those of the birds, and the young reptiles make their first meals of embryo brush turkey.

CARRIED IN A POUCH

There are some paragon nursing fathers amongst the frogs. One, a minute species from Chile, known as Darwin's frog, swallows the eggs as fast as laid by his spouse and tucks them into a pouch beneath his throat. The eggs hatch, and the tadpoles feeding on their yolk sacs soon require more accommodation. Conveniently the pouch spreads, first down the underside of father's face, then along his sides, until it nearly covers his entire body. He is practically a walking nursery, and so remains until the last of his fifteen or so children have emerged as fully formed froglets.

A common continental amphibian is the well-named midwife toad. The male gathers the eggs, which are laid in long strings, winds them round his hind legs, and thus fettered struggles slowly to some underground retreat. At night he cautiously creeps forth and moistens the eggs in a convenient pond, or failing this bathes them in dew. Thus he continues until instinct tells him that the eggs are nearly ready to hatch, when he hurries to the nearest water and releases a swarm of tadpoles.

CANNIBALISTIC MOTHER

A cannibalistic mother would seem to explain the nursing father amongst many of the lower vertebrates. If the male giant Japanese salamander, for example, did not take charge of the strings of eggs laid by his partner, they would quickly be devoured by her.

In the long list of nursing fathers among fish can be numbered the little stickleback, already noticed amongst the nest builders. This fish, which abounds in ponds and ditches,



FIRST AND LAST STAGES OF A BEAUTIFUL MOTH

DORIAN LEIGH

This unusual photograph shows the Promethea moth depositing its eggs upon the beautiful Lady's Slipper. Pairing takes place in the air, and the female usually dies soon after the eggs are laid.

is wonderfully adaptable. It thrives also in brackish and in salt water, using whatever material is in season for its home-making.

When turning the boulders in search of shell-fish, one often comes on hard clusters of beady objects of variable hue, white, pinkish or green. These are the eggs of gobies, or the little bullheads, and the male fish is usually to be found in the vicinity, putting a bold face on whatever odds may be against him in the defence of the eggs. The butterfly blenny and the butter gunnel, or nine eyes, generally tuck their eggs safely within an empty shell, blocking the entrance with their own persons, and glaring defiance at all comers.

Low down in the tide range during spring one meets the male lump sucker, a heavy dumpy fish ill-fitted for swimming, but clinging tightly to any anchorage by means of a

big elliptical sucking disc upon its breast. This creature, whose brooding habits have earned it the name of hen fish, endeavours to keep free from harm some one hundred and thirty thousand eggs. It is a losing fight, for other fish, crabs and whelks take their toll from below, early spring gales dislodge masses of eggs from the rock cranny sheltering them, and sea birds attracted by the spoil in all probability also lay siege.

In the long bony pipe fish which always forms part of the shrimper's catch, nursing fatherhood reaches its peak. The pipe fish is simply a very attenuated version of the famous sea horse, and broods the young in precisely the same manner. Two flaps of skin on the male's under-surface fold one upon the other to form a pouch and in this the female deposits the eggs. A unique feature of this pouch is

that it develops at this season a spongy lining, richly supplied with blood vessels; the eggs become partly embedded in this, and apparently draw nourishment therefrom, as do embryo mammals from the placenta.

Sea horse and pipe fish certainly need a good start in life, for they are the feeblest of swimmers. They are largely passive travellers, clinging by their prehensile tails to drifting weeds, and so wandering without a course or means of directing one, at the mercy of winds and currents. It would appear to be a very precarious existence.

ALMOST WITHOUT A BODY

Also in the shrimper's catch occurs the little crustacean known as a sea spider, a creature virtually without a body, for the internal organs are largely distributed through the basal segments of the exaggerated legs. In summer one finds the male of the sea spider carrying a little bag containing the eggs. He carries the bundle

with him as he creeps about the rocks, plunging his long curved beak into sea anemones.

Worms might be regarded as the least likely to evince any parental care. Certain marine bristle worms, however, display something very like it, and again the male is the responsible party.

LIFE MEANS DEATH

On the shores of the English Channel lives a worm much prized by fishermen as bait, and not unlike the cat worm sold in fishing-tackle shops. Male and female share a tube made of sand, and when the female has laid her eggs, the male incubates them by causing a stream of water to pass continuously over them by rhythmic undulations of his body. The mother, having discharged the eggs, is so weakened as to be a mere encumbrance, so her practical helpmate philosophically devours her. To her the new life means death, but to him a presumably excellent meal.



REPTILE THAT CRUSHES ITS PREY

The boa-constrictor produces its young from eggs, though those shown in the nest were laid by a bird. When this photograph was taken the snake had just shed a skin.



CHARLES ALFRED HAMILTON

LARGE ANIMALS LIVE LONGER THAN SMALL ONES

There is relationship between longevity and size. The larger machine usually takes longer to wear out than does the smaller one. Oxen, given good conditions, live about forty years.

DURATION OF LIFE

WHATEVER the nature of the animal—man, mouse or amoeba—it is travelling to a goal of some kind, and the time it takes to run its course is always a matter of interest. Often the age limit of an animal may be of direct economic importance. If, for example, we knew the potential life spans of the various whales their conservation might be an easier matter. At present, legislation on their behalf must perforce be founded largely on assumptions.

Save where domestic creatures are concerned, exact knowledge of any particular animal's life span is hard to obtain. Major Stanley Flower and Sir Peter Chalmers Mitchell have amassed elaborate statistics of animal longevity based upon observation of captive specimens. But as the authors point out, such figures give comparatively little or no indication of the same animal's potential longevity under natural conditions.

Once a creature comes under human supervision it is sheltered from natural enemies, drought, famine and a hundred other dangers, as well as from ailments which might tend to

shorten its career under normal conditions. Even so, such figures cast an interesting light on animal viability, as the life span is called, at the same time dispelling many popular illusions regarding the length of life of such animals as the raven, donkey and carp, which tradition has erroneously invested with Methuselah-like longevity.

In the first place, the longest-lived animal, regarded as a species and not as an isolated exception, is probably man, if we disregard for the moment the dwindling race of giant tortoises. Apart from wars and other disasters, the average man of today enjoys far better chances of attaining to a ripe old age than did his forbears of even a century ago. Improved sanitation, an increasing appreciation of the value of sunlight, fresh air and good food, and the wonderful advances made in medicine all tend to prolong life, and before very long perhaps the centenarian will cease to be an interesting curiosity.

The figures gathered to date tend to show that there is a marked correlation between longevity and size. The larger machine takes



GORILLA AT HOME

For their size the man-like apes are probably the longest-lived mammals next to ourselves.

longer to wear out than does the smaller one. Amongst mammals, statistics seem to show that vegetarian or mixed feeders wear out more gradually than do carnivores or flesh eaters, though it must be admitted they are obliged to spend much more time in feeding, a bigger bulk of fuel being required to obtain the same amount of power. On the other hand, they lead less strenuous and hazardous lives than do the flesh eaters.

EARLY MATURITY—EARLY DEATH

For their size the man-like apes, the gorilla, orang-utan and chimpanzee, are very likely the longest lived mammals next to ourselves. It is only recently that we discovered how to keep these delicate creatures successfully in confinement, so that exact information on this point is still very fragmentary. Chimpanzees and orangs have been known to live up to forty years in captivity. It may well be that, like

the human beings native to tropical countries, they "burn out" much faster than do the people of the bleak but bracing northern hemisphere.

As we pass down the primate scale, there is a marked tendency to mature and die faster in accordance with diminishing size. A common rhesus monkey is senile earlier than a baboon, and a rhesus can generally be counted upon to outlive a marmoset. Yet here, as in all things else, the exception proves the rule. The honey-bear or kinkajou of tropic America may live for forty years, much longer than any monkey of the same size. The porcupine ant eater or echidna may also live to be over forty, but this is one of the lowest of all mammals, and has so much in common with reptiles as to be outside present considerations of size in relation to longevity.

SOMETIMES A CENTENARIAN

Contrary to popular belief, the elephant does not live for centuries and all stories of its extreme longevity are of such a hearsay or traditional nature as to be at best unconvincing. An elephant can breed when just turned ten years old, and though it may occasionally see a century out it usually develops signs of senility at about half that age.

The hippopotamus and rhinoceros can breed up to forty years of age, and most of the bigger grazers and browsers—camels, giraffes, horses, oxen, sheep, etc.—will, given good conditions,



FORTY YEARS IN CAPTIVITY

Chimpanzees have lived forty years in captivity. They probably die younger in their native haunts.



MARCUSWELL MAXWELL (MONDIALE)

PREFERS TO HUNT AT NIGHT

The rhinoceros can breed up to forty years of age. It prefers to live singly or in pairs and to do its hunting for food when the heat of the day is over.

live till about forty. A camel can be worked hard for over thirty years, and there are a few donkeys of this age still in harness in our own country. In the East a donkey's years seldom measure a quarter of a century.

DONKEY'S BURDEN

This is hardly surprising, seeing that the Oriental donkey, though smaller and slighter than the British breed, is normally saddled with loads that would appear stupendous to western eyes. There is a saying in the Near East that "a merchant first makes up his load and then goes out to hire an animal to carry it." As donkeys are far more numerous in the Near East than any other beast of burden, they usually have to bear the brunt. And, whatever the weight of the load, the eastern merchant invariably adds to it his own usually bulky person. By way of consideration for his pack animal, he makes his wife (or wives) walk!

Cats, bears and sea lions may live from fifteen to forty years, according to size. Lions, at least in zoological gardens, are easily the

longest lived of all the cat tribe. But taking size for size the mammals certainly read an eloquent brief for vegetarianism. A fruit bat half the size of a fox enjoys twice the fox's age. A common insect-eating bat runs a dead heat with the omnivorous mouse or rat, namely two and a half years. Whales, as stated above, are largely an unknown quantity as regards their potential life spans. The mystery may one day be cleared up, thanks to the recent device of marking them with nickel darts or miniature harpoons, much as fish are marked with discs, or birds are ringed.

DIET OF CARRION

The known age limits of birds discount the meat versus vegetables theory of longevity. The ostrich, eight feet high and two hundred pounds in weight, is far behind the vulture, which on a diet of carrion often lives for nearly half a century. The raven, popularly supposed to outlive the centuries, is, according to the authorities of the Tower of London, where ravens have long formed part of the "garrison,"

a very old bird at less than half the vulture's age.

Owls and their near relatives the parrots, are probably the longest-lived birds. The big eagle owl of northern Europe has lived in confinement for over sixty-eight years, and there are many authentic cases of parrots and cockatoos exceeding even this. Parrots not only evince great age in the condition of beak and claws, and an unbecoming poverty of feathers, but also by sometimes glibly using the catch phrases of a long-departed generation.

REPTILES GROW RAPIDLY

Reptiles, akin though they are to beasts and birds, present entirely different problems as regards their age limits. Like amphibians and fishes they tend to grow very rapidly during their earlier years, and then settle down to increase their bulk slowly but continuously throughout life. Great size is not necessarily a criterion of reptilian age, although the oldest known reptiles are usually of impressive proportions.

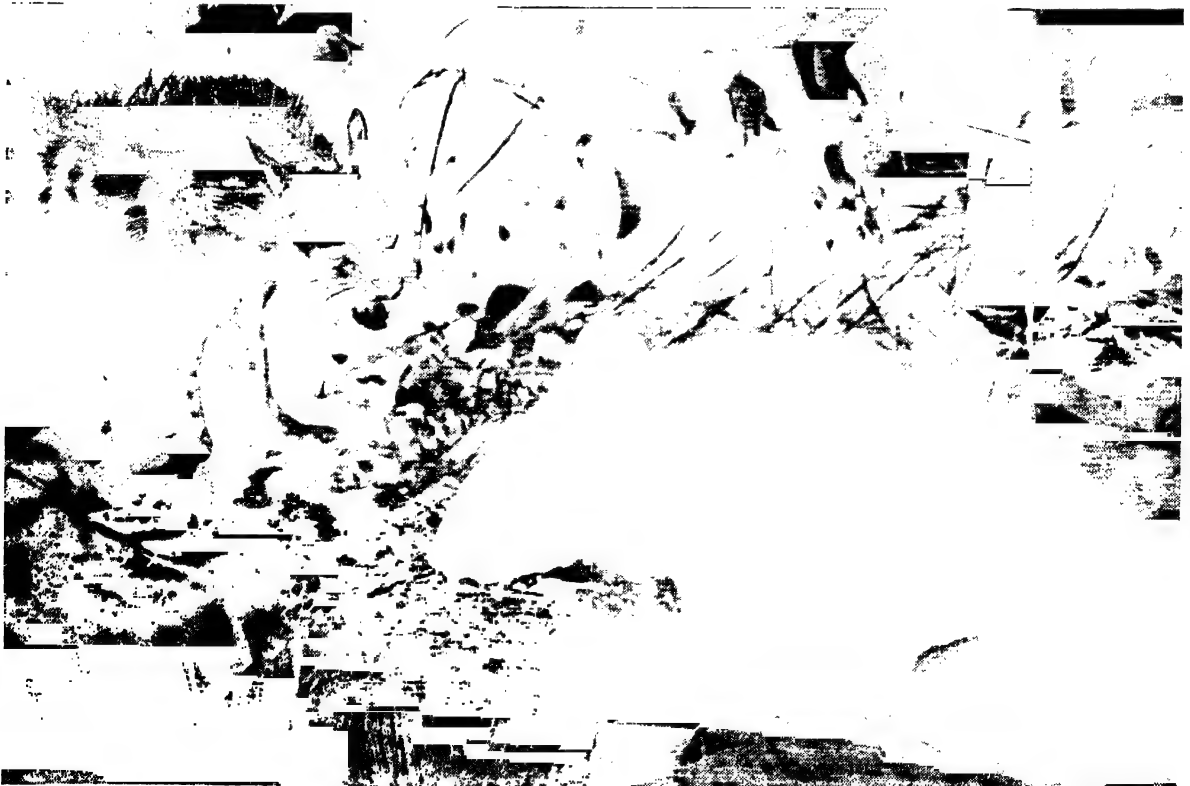
Lord Rothschild at one time made a cult of giant tortoises. Several in his famous museum

at Tring weigh over five hundred and fifty pounds each, and one of this weight can safely be estimated to have seen at least two centuries. One monster still living on St. Helena is known to have been almost the same size when it was a contemporary of Napoleon in his exile. In Peterborough Museum is the shell of a little Grecian garden tortoise which is said to have graced the cathedral close for two hundred and twenty years.

ARCHBISHOP LAUD'S TORTOISE

Almost as famous is the tortoise once owned by Archbishop Laud, the shell of which is now in the library of Lambeth Palace. The reptile is reputed to have ambled about the palace lawns for one hundred and twenty-three years, and was then, as a label attached to the shell quaintly says, "mortally killed" through the curiosity of a gardener who dug it out of its winter retreat in order to settle a wager regarding the creature's age.

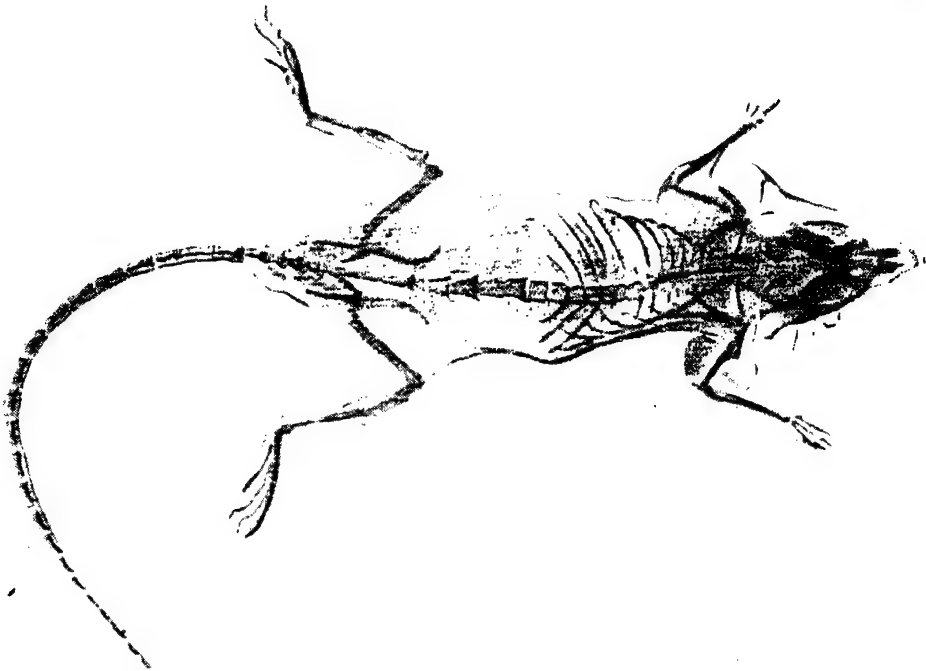
All available figures show forty years to be a very ripe age for a crocodilian of any kind, and much the same applies to giant snakes.



SOME BEARS ARE OLD AT FIFTEEN

WIDE WORLD

Bears (right) may live from fifteen to forty years, according to size, and provided they are not confronted by a hyena (left) or other enemy who proves the stronger in a contest.



X-RAY PHOTOGRAPH OF A MOUSE

MONDIALE

The omnivorous mouse runs a dead heat as regards length of life with the rat and the common insect-eating bat, namely two and a half years.

Records of the ages of amphibians show that the giant salamander of Japan, which reaches five feet in length, may live for half a century. This is not long in proportion to its size, for many newts of only a few inches in length have lived in aquaria for more than twenty-five years. The toad, another creature reputed to outlive the centuries, is not known to live any longer than the common newt.

Possibly many fishermen's tales have centred round the age as round the size of the catch. A classic example is the story of the rustic who claimed to have caught a pike "centuries old" because he had found an Elizabethan coin inside it.

TELLING THE AGE OF A FISH

Today science leaves no ground for picturesque assumptions regarding a fish's age, provided it is of the kind having a hard bony skeleton and well-formed scales, features distinguishing the bulk of living fishes. Within the skulls of such fishes are two flattened bones, often suggesting porcelain, and having clearly marked upon them a series of concentric rings. These so-called ear bones are easily found in the ling and bream, being there exceptionally large.

The rings mark periods of summer growth, and correspond with similar rings marked upon the scales. Here then are two reliable age indicators, and they tend to show that, as in most animals, great size implies a correspondingly generous fill of years.

SHORT-LIVED STICKLEBACKS

The golden orfe, goldfish, plaice, bow-fin, bass, mirror carp, and halibut live from twenty-five to forty years. Often some fishes, particularly carp, suffer from a fungoid disease giving them a spurious "rime of age." Skate, herring, pike-perch, bass, trout and the Australian lungfish live for fifteen to twenty years. All records show that the little shore fishes of Great Britain such as blennies, gobies and sticklebacks live for a few years only.

Amongst the various groups of invertebrates, life spans so far as they have been ascertainable vary considerably. Shore crabs kept in aquariums have taken three years to attain full size, changing their shells seventeen times in the process. A lobster will change its clothes fourteen times in the first three years of life, then slow down to half this number of changes in the next five years, for shell

casting becomes a more difficult and exhausting business with each successive effort.

A lobster's eggs hatch out in the course of some months. The eggs of the equally aquatic brine shrimp, so largely used as a fish food by aquarists, will keep fresh in a perfectly dry condition for a year at least, perhaps much longer. Few insects survive more than a year in the mature form, but many may spend years in the larval form, the goat moth and stag beetle being familiar examples.

The shelled molluscs like the whelk and the oyster provide tangible records of their ages by piling up deposits of mineral matter during the warmer months when food is abundant, and the animal at its maximum of activity. Any snail or clam shell presents a series of ridges, lines of growth, each of which marks a year's increase in size. Again size and longevity go hand in hand, as may be seen in quite a hurried survey of any fairly extensive collection of shells, whether land, freshwater or marine.

Two factors may serve to mar the record, but both are exceptional. Some desert snails, faced with famine, can sleep through a time of scarcity—even though it lasts for a year or more. Again, extensive injury may cause the shell to be so patched and plastered that the original sculpturing, largely provided by the lines of growth, is almost entirely effaced.

In such soft-bodied creatures as sea anemones and coral animals the life span varies enormously. The tiny builders of the Great Barrier Reefs and atolls may each live for a few

days only. The sea firs of English waters, near relatives of the reef builders, are largely annuals, the main growth dying in autumn but ensuring next year's supply by disseminating eggs.

The sea anemones might be regarded as equally ephemeral, but here a surprise awaits us. The exact limitations of a sea anemone's life are not known, perhaps they never will be. The oldest aquariums in the world, institutions of just under half a century's establishment, shelter sea anemones that were placed in the tanks on the opening day and have remained there ever since, growing slowly and imperceptibly, as full of vigour apparently as when first prized from their native rocks.

An insect's life is short. A mayfly, for instance, is old four hours after it has ceased to be a pupa, and a dragon-fly lives no more than seven weeks. The risks run by the insect world are obvious. As Prof. J. B. S. Haldane points out, "A man coming out of a bath carries with him a film of water of about one-fiftieth of an inch in thickness. This weighs about a pound." That is not a serious matter to a human being, but "A wet fly has to lift many times its own weight, and, as everyone knows, a fly, once wetted by water or any other liquid, is in a very serious position indeed. An insect going for a drink is in as great danger as a man leaning over a precipice in search of food. If a fly gets wet it is likely to remain so until it drowns."

A short life, it would seem, and by no means necessarily a particularly happy one.



DORIAN LEIGH

A DRAGON-FLY LIVES FOR SEVEN WEEKS

Reading from top; The larva case breaks. Head, back and legs work themselves out. The dragon-fly has stripped off the whole of its former covering. A tentative raising of the wings. Fully developed. Ready to fly.



TEETH IN THE WALLS OF THE STOMACH

The lobster's pincers are more effective than the rasp-like teeth of the sea urchin. They can chop up a mussel shell into small pieces which pass to three teeth fitted to the walls of the stomach.

FEEDING AND SLEEP

SCARCELY any known plant or animal is inedible—to somebody. It is probable that even the tropical trigger fishes with their highly poisonous alkaline flesh have natural enemies. There are certainly not many plants or animals which man does not use for food in some part of the world. Shellfish of all kinds, worms, insects and insect larvæ, eggs and mice all figure on the menu of civilized man. The kinds of food which can be eaten are so multitudinous that we shall here consider rather the different ways of absorbing them.

"All flesh is grass" said the sage of old, and it is literally true that all animal life is in the first instance dependent upon vegetables, which largely derive their sustenance from sunlight, air and soil. The leopard that lives on cattle eats grass by proxy so to speak, just as does the tiger shark, devouring fishes which in the first instance were nourished on the minute plant life collectively known as plankton.

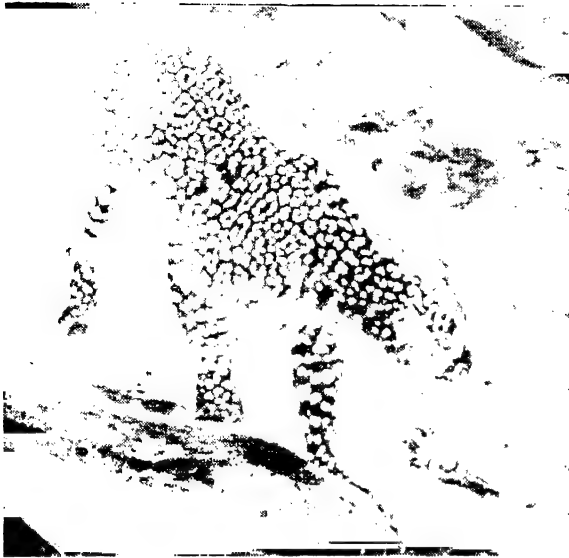
All animals can be roughly gathered into two great gastronomic armies, one living on minute organisms in bulk, the other selecting larger food and eating it as a bolus or piecemeal. Feeders of the first order were the earliest of all diners. They thronged the seas in the persons of the minute chalk animals, the rotifers and other microscopic or semi-microscopic forms. They took their food by sweeping all that the surrounding water contained into their maws by violently lashing hairs, or cilia, and though some selection may

have been observed when the food reached the diner's interior, it was brought there haphazard in the first place, with much that was waste.

In this way the minute animals already mentioned still feed, and so also do many worms, all sponges, sea squirts, barnacles and the vast army of bivalve molluscs—clams, oysters and scallops. Even the giant three-foot-long clams of the Great Barrier Reef feed thus on minute plants which are swept into their crops by means of countless microscopic whips.

Quite recently it was discovered that the giant clam had a special provision for getting enough of this food to sustain its enormous bulk—and one giant clam may make a meal for six men. It appears that certain portions of the clam's soft body form breeding grounds for the microscopic plants, so that the monster has always a reserve on the premises, apart from what it sweeps into its interior in the ordinary course of feeding.

Early in the world's history—early, that is to say, as regards animal life—there appeared another class of feeders which ate minute organisms but in a different way. Many worms and other soft-bodied creatures burrow into soil, and as they burrow, swallow all that crosses their path and force it down their simple digestive tracts. This heterogeneous mass of stuff is sorted out in the process, nutritive matter passing into the blood stream and the

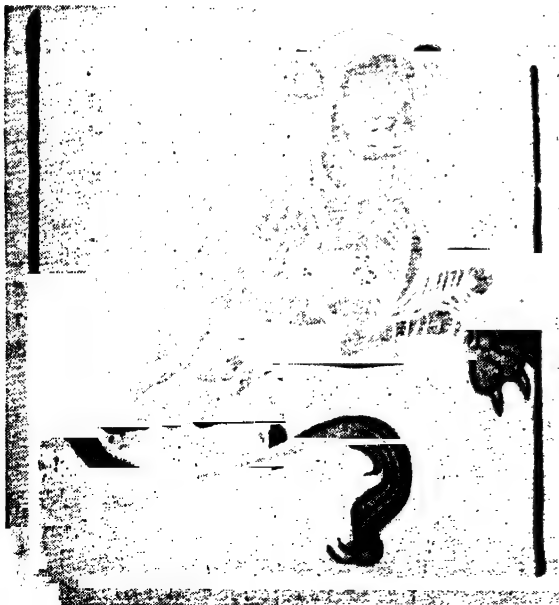


AMERICAN MUSEUM OF NATURAL HISTORY, NEW YORK
CUNNING HUNTER

The leopard, or panther, is not fussy about its diet, being willing to devour anything it can catch.

waste being cast out via the vent. Familiar examples of such waste are the worm castings usually seen on every sandy beach and garden lawn.

Long before the first vertebrates appeared an advance was made upon these two simple ways of taking food, both of which permitted only relatively soft material to be dealt with.



BRITISH MUSEUM (NATURAL HISTORY)

IN LESS LEARNED DAYS

The leopard as pictured in a volume published in 1491. The animal's head is almost human.

A sea anemone may swallow a whole whelk shell, but it can only absorb the whelk. The shell must be cast forth, or at most only slightly dissolved. But some molluscs developed an internal shell made in several pieces, working one upon the other, and forming a very effective grinding mill. One can find such a mill, about as big as a runner bean, in the bubble snail, found on the sandy south coast beaches of England.

TEETH IN THE STOMACH

The sea urchins also developed fine sharp teeth, working one upon the other, but they could still only serve the purpose of a rasp, much as do the horny tongue teeth noticed when glancing at the snail's tongue. More effective grinding organs appeared in the complex tongs, forceps, scissors and brushes seen in the many modified limbs, or mouth parts, of insects, crabs and lobsters. A lobster can chop up a mussel shell into small pieces which pass to three teeth fitted to the walls of the stomach, and known as "the lady in the chair."

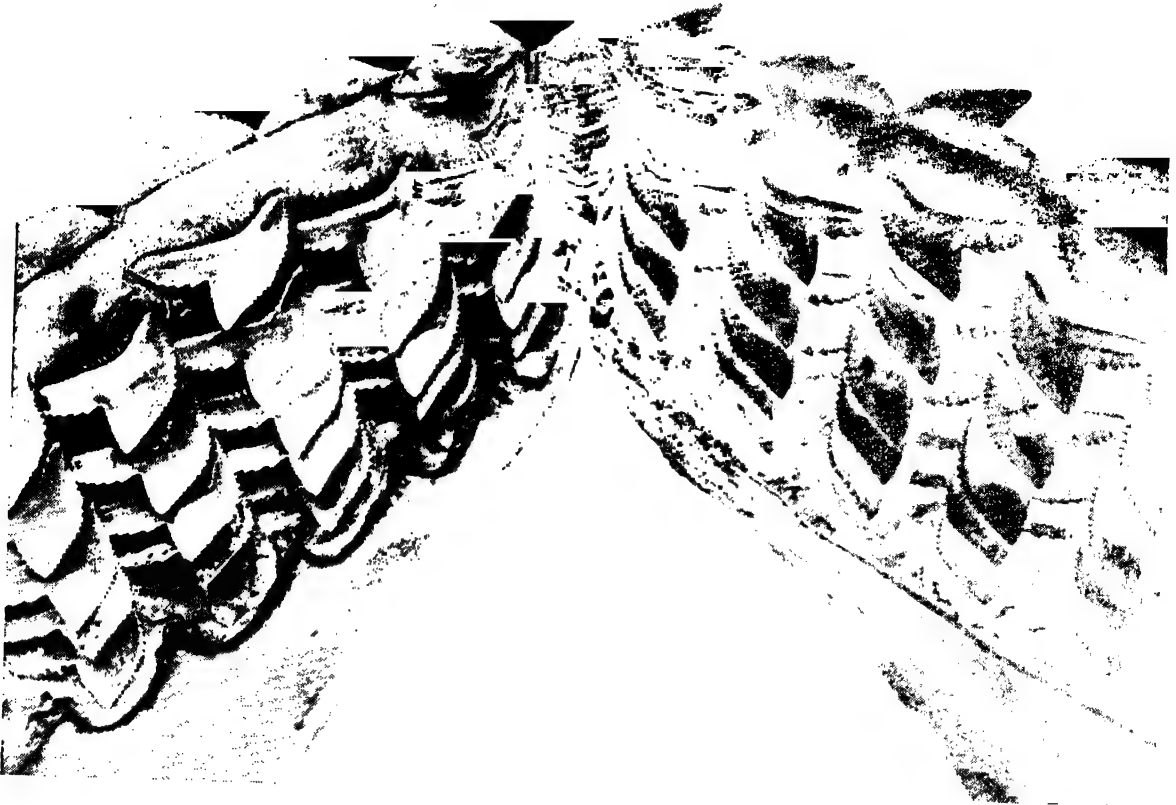
True teeth appeared first in the fishes, but not until the group was already well established. The first fishes had suctorial mouths, or at most sucking mouths ringed with file-like horny teeth, as in the common lamprey.

ASTONISHING SWALLOWING FEATS

True teeth are seen at their simplest in the sharks and rays as a roughening of the skin forming a series of sharp plates covering the lips. It must be admitted that this roughening was very impressive at times. One extinct shark known as carcharodon had a mouth big enough to accommodate a man, and ringed with rows of saw-edged teeth each about four inches long.

In the bony fishes which evolved later, teeth have assumed an infinity of forms. Often they are so long as to protrude far beyond the fish's face even when its mouth is shut. The common rock salmon, really a giant blenny, has teeth strong enough to break oyster shells. The angler's teeth work on hinges, forming a bristling barrier which no fish, once swallowed, can hope to repass. The wrasse can nibble hard barnacle shells off the rocks, and pass them on to other teeth in its throat, where they are ground to powder.

A large percentage of fishes bolt their food whole, and some are capable of astonishing swallowing feats. The pike and angler fish



SHARK'S DENTAL ARMOURY

WIDE WORLD

Upper jaw of a tiger shark. As soon as a tooth on the upright row is lost or broken another springs erect to replace it. The fish to which these teeth belonged was captured by the Bermuda Oceanographic Expedition.

often choke to death as a result of swallowing prey too large for them. A fish of the deeps, however, though not so large as a herring, can swallow a fish three times its own length, the stomach conveniently stretching to accommodate the mouthful. It sometimes happens that the mouthful protests to such purpose that both diner and dinner are carried up to the sea surface, where some passing sea bird plays a last part in the tragedy. In spite of this fish's swallowing abilities, its teeth are little more than a fence to prevent the prey, once caught, from escaping.

MAINED BY MILLIONS

Some fishes literally use their teeth-filled jaws as mincing machines. A shoal of piranha (a Brazilian fish no bigger than a roach) have been known to destroy a man and his horse. The edible blue fish of America follows shoals of sea perches, chopping off their tail portions as neatly as one might with a pair of shears. Some of the fishes live to swim minus their tails, the dorsal and anal fins closing in behind to

replace the missing tail fin, but it is estimated that hundreds of thousands of millions of fishes are maimed past recovery within a blue fish season of about one hundred days.

LOBSTER'S AUXILIARY PINCERS

With all the advantages which the fishes enjoyed as regards organs of propulsion, circulatory system and breathing over the invertebrates, the latter had anticipated them in tactile organs. Crustacea are better off for hands than many mammals. The common lobster can utilize its pincers with almost the neatness and finesse of a watchmaker manipulating his tweezers, and in addition has two auxiliary pairs of pincers among its walking legs. A crab will take a carrot in one claw and eat it whilst keeping off would-be participants in the meal with the disengaged claw.

Apart from vertebrates and arthropods or jointed animals—crustacea, insects, etc.—only one other group of creatures seems to have developed satisfactory tactile organs. The octopods and cuttle fishes, highest of the mollusca,



BABY OCTOPUS

WIDE WORLD

The octopus eats crabs and oysters. It does not crush their shells, but pulls them apart with its tentacles.

have developed the molluscan "foot," as seen in the snail and pond mussel, into eight or ten long arms covered with sucking discs. The cuttle fish, a typical ten-armed mollusc, tucks two extra long arms into pockets, one on either side of the head, when not in use. These can be shot out at lightning speed, and the tips attached to passing prey—usually a fish.

LAIR OF THE OCTOPUS

The octopus, unlike the squid and cuttle fish, seldom hunts in open water. Instead it lies hidden in a rock fissure, and when a crab comes within range, unrolls one tentacle and attaches the tip to the front of the crab's shell. Only the lobster and a few species of crab offer any resistance; the victim generally appears conscious that fighting is futile, and a big octopus will thus catch a score of crabs in succession, storing them amongst its coils until wanted.

The arms, tapering to whip-lash tips, are deftly used to dismember the crabs and extract

the meat; the shells are never broken, as each arm bears some three hundred tentacles, a terrific pull can be exerted; even the valves of a big oyster shell can be successfully forced apart.

GIANT SQUIDS

One may gauge the awesome power of the giant octopods of Australasia when it is stated that a specimen forty feet across the arms has about two thousand five hundred tentacles ranging in size from that of a threepenny bit to a breakfast saucer. In the giant squids of the Atlantic the long arms may measure thirty feet, and in all squids the large suckers are reinforced as to their rims with strong horny rings set with sharp hooks, or curved spines.

In reptiles we see a great advance in dental structure. Always the teeth grow from below upwards, are heavily enamelled, and as a rule grow throughout life, worn teeth being supplanted by new ones ever thrusting upwards from the socket. In crocodiles the teeth are



HAROLD BASTIN

LONG-ARMED MONSTER

Squids' arms often attain a length of thirty feet. They are equipped with sharp hooks, or curved spines.



WIDE WORLD

ALLIGATORS BURSTING FROM THEIR SHELLS

The alligator's denture differs from that of the crocodile in having the fourth tooth of the under jaw projecting into a hollow in the upper jaw. Crocodiles have this tooth fitted into an external notch.

fitted one on top of the other, like the hats of a circus clown. Usually the sockets are very shallow compared with those of mammals, and in many reptiles the teeth merely lean up against a ridge on the jaw bone, where they are simply held in position by the gums.

The hollow teeth which convey the poison of venomous snakes are ranged one behind the other, so that when one is dislodged by accident, as not infrequently happens, another immediately takes its place. In all snakes the teeth point throatwards, and though this may very effectually prevent the escape of a lively dinner, as in many fish, it can also lead to the diner's untimely end. Once a snake has gripped its

prey, it must swallow it entire. There is no relinquishing its hold and ejecting an undesirable mouthful seized in haste. Each movement of the jaws only forces the bolus further into the interior.

This accounts for a snake sometimes choking to death. Its "eye has been bigger than its stomach" as we say, and if another snake almost its own size has similarly gripped the other end of the same victim, disaster is bound to follow.

In one snake there is an extraordinary development of tooth-like structures where such would not be expected. The true teeth of the African egg-eating snake are almost negligible, but the inner surfaces of the neck vertebrae have



WIDE WORLD

GREEK TORTOISE IN ITS NATIVE HAUNTS

Turtles and tortoises discarded their teeth for horny sheaths at the edges of their jaws. Other animals find teeth a disadvantage; duckbills and some whales are born with teeth which they lose in adulthood.

sharp enamel-tipped points. The snake's head, though no thicker than one's finger, can stretch to accommodate a hen's egg, and when this reaches the neck teeth they crack the shell and release the yolk into the snake's interior. There are cases known of this snake attempting to crack a china nest egg, such a meal invariably proving fatal.



DEADLY HAMADRYAD

The poison of venomous snakes is passed through hollow teeth, which when broken are immediately replaced. In all snakes the teeth point throatwards.

In the long chain of evidence establishing the reptilian ancestry of birds, a very important item is the possession of teeth by many birds in the prehistoric past. Veritable teeth set in sockets were present in both jaws of the "almost bird" archeopteryx, and were in vogue amongst the true birds which followed after for many millions of years. Gradually they disappeared, at first from the front upper jaw and later entirely, being represented only by serrations of the bony structure and covered by a thin horny sheath, in which state they persist amongst some birds to the present time.

For some reason, teeth persisted in all but one or two of the mammalian groups which developed parallel with the birds. At first mammalian teeth presented the same curious

uniformity as did the general make-up of the creatures wearing them. Amongst the earliest mammals none was obviously carnivorous or obviously herbivorous. But as the hairy creatures pioneered and steadily widened their range of activities, their teeth altered to suit each fresh exigence as it occurred, and today mammalian teeth present a far wider range of size, shape and function than do those of reptiles.

A few mammals have discarded teeth, just as the turtles and tortoises amongst reptiles abandoned them, for horny sheaths to the edges of the jaws. The very young duckbill has functional teeth, and there are milk teeth present in the jaws of embryo whalebone whales, though these vanish in later life as being detriments rather than assistants to the animal's peculiar mode of feeding.

ANIMALS WITHOUT TEETH

The whalebone whales mimic the oyster in gulping down vast quantities of minute food after passing it through a sieve, the sieve in the case of the whale being those horny curtains of whalebone or baleen which are really a peculiar development of the palate. The insect diet of the ant eaters has eliminated the necessity for teeth, although there is evidence, particularly in the case of the South African earth bear, that these strange creatures are the descendants of toothed ancestors.

Teeth are among the surest clues to an animal's way of life, and our own bear eloquent testimony to the fact that almost everything is grist to the human mill in matters of diet. Increasing reliance on soft prepared foods is tending to eliminate our back teeth, and to reduce the size of our canines, but in most other primates these last remain well developed, either for use as weapons or as effective nut crackers.

TUSKS THIRTEEN FEET LONG

Any of the teeth, like limbs or other features, are liable to extravagant exaggeration to meet peculiar requirements. In rodents the incisors are powerful chisels; in the elephant, tusks for stabbing a foe or uprooting trees. An extinct Indian elephant had tusks each thirteen feet long, and the two together weighed over four hundred pounds. Much more frequently it is the canine teeth that are prolonged to form tusks, and the upper are more often thus developed than the lower. The walrus uses its upper canines to haul itself on to ice floes, the water



BEBE UNDERSEA EXPEDITION (WIDE WORLD)

BLACK ASTRONESTHES PURSUING LUMINOUS PREY

Many fish bolt their prey whole, being capable of amazing swallowing feats. A deep-sea fish, not so large as a herring, can gulp down a fish three times its own length, its stomach being extremely distensible.

deer and muntjac employ similar teeth for fighting other deer or unearthing roots and bulbs.

In the pig tribe both upper and lower canines attain tusk dimension, and the lower teeth only reach a large size in the horse, camel, rhinoceros and some other herbivores, who utilize such weapons only in duelling during the mating season.

ANIMALS THAT USE SHEARS

One race of animals, the kangaroo, has put the incisor teeth to a unique use, quite contrary to the general purpose of such teeth, which is chiselling hard substances. The two lower incisors appear to have no kinship with the upper incisors, which are numerous and peg-like. Instead, the lower pair are developed into two large blades, which being movable, work upon each other like the blades of a pair of shears, and are used in precisely the same manner for cutting grass.

The tusks of the hippopotamus are also in the nature of shears but function in a more usual manner, the lower pair merely cutting against two upper teeth. So great is their strength, that not only can they cut a whole truss of lush vegetation by a single snap, but in emergency even halve a native canoe or a man. They are also used with terrible effect in duelling.

Grinding teeth, which always occupy the hindermost parts of the jaw, usually present complex sculptured surfaces, sometimes showing,

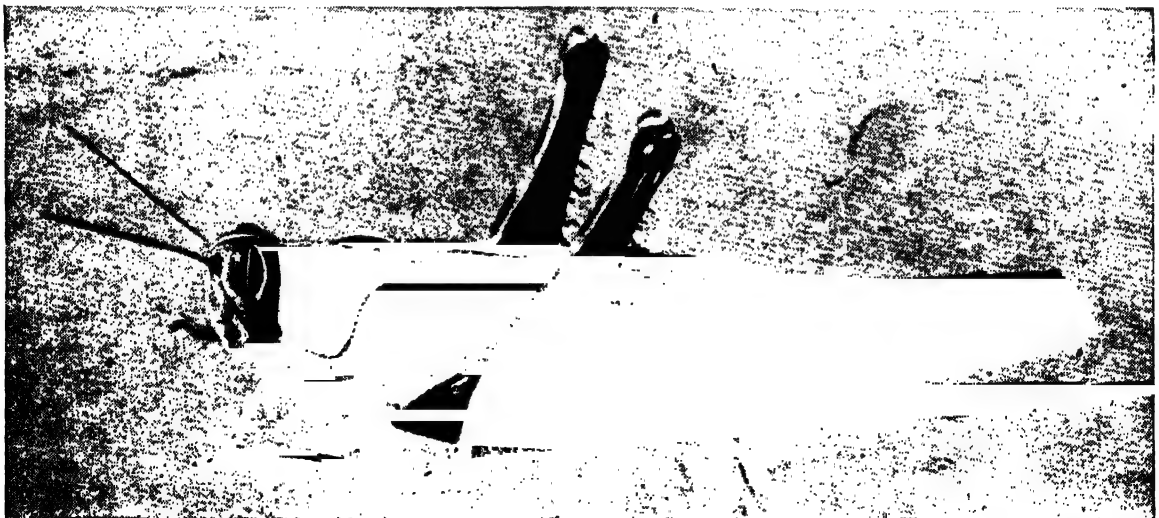
as in the musk ox, intricate designs formed to grind the hardest food, and so extract the maximum nutriment from the least promising material. In the elephant these teeth, reduced to two in each jaw bone, grow from behind forward, the rearmost teeth gradually supplanting the forward grinders as they are worn away.

Once a tooth is formed it is usually a completed structure, but an exception is provided by the horse. The roots of its teeth remain open for eight years or more, and so draw more than usual support from the blood stream, enabling them the better to cope with a hard, dry, farinaceous diet. Such teeth may remain in full vigour for forty years.

ENIGMA OF THE NARWHAL

Mammalian teeth, however strange or complex, usually yield the secret of their peculiar functions to patient study. The teeth of the narwhal or sea unicorn are exceptions, for they remain enigmas. In the male these present two spirally twisted rods of ivory, growing side by side from the front of the upper jaw, the left-hand tusk usually being the longer. They are quite inexplicable since the animal seldom seems to need them either for duelling or repulsing foes, and they can certainly be of no service in obtaining food, the creature's diet consisting chiefly of cuttle fish and small crustacea found swimming in mid-water.

The old adage that we dig our graves with our teeth need no longer apply to man.



SILVER GREY DESERT LOCUST

WIDE WORLD

The eternal search for food inspires vast mass movements of animals, which, as in the case of locusts and grasshoppers, quite frequently cause enormous damage to human food supplies.



METHODS OF FOOD STORAGE

(Left) Pouched animals: monkey, gopher-rat, pelican and adjutant stork. (Right) Animal with distensible stomach: the black swallower, a deep-sea fish, before and after attacking a squid several times its own size.

Painless dentistry has rendered the phrase meaningless. It still holds good with the wild animals, however, and when once a creature's teeth decay, their owner is doomed. Accidents and abnormalities in an animal's dental armature, though not frequent, usually spell disaster.

Occasionally, elephants are met with having six or seven small tusks growing in one socket. The immense curved tusks of the wart-hog, if deflected from the normal curve in early life, grow straight out in front of the animal's head, making it difficult to root and feed. In still worse case is the rodent which snaps one or both of its lower incisors.

• VAST MASS MOVEMENTS

Only continual use enables these teeth to be kept within reasonable bounds, and once gnawing is made impossible by the loss of their bevelled tips the teeth literally run riot. Rodents of all kinds have been found with these teeth curving right up over the creature's head and penetrating the eyes or ears.

The eternal search for food has largely

determined the distribution of animals, including man. It inspires also vast mass movements of animals which, as in the case of locusts and grasshoppers, not infrequently result in vast damage to human interests.

FOOD STORERS

Most animals eat as they go, and most carry reserves of food stored about their bodies in the form of fat, but only those of the northern hemisphere seem to have emulated man's well-designed granaries and other food stores. The habit is confined to a few groups of animals only, and to social insects with which food stores are a natural part of the general régime. Some monkeys certainly store food in their cheek pouches, but this is only a very temporary measure, the outcome of living in a riotous society which makes it imperative to grab all one can when opportunity offers and then enjoy it at leisure when some measure of privacy is possible.

The chief mammalian food storers are rodents, though the rule is by no means universal, even amongst northern species. The

beaver is a classic example, and so also is the squirrel. Recent observers have proved that not only does the Canadian grey squirrel make large numbers of nut stores—the locations of which it often forgets—but it even stores dead birds and fungi. These are very cunningly lodged in the forks of tree branches, so that the bird's head or toadstool's cap lies across the forks and the bird's body or the fungoid stalk dangles below.



MONDIALE

FEATHERED HOARDER

Some magpies, like ravens and jackdaws, have a passion for collecting bright or ornamental objects.

Nuts and berries are invariably carried to the dump in the animal's mouth, and generations of mouth cramming have stretched the cheeks of the American gophers till they present pouches rivalling those of the monkeys. When a gopher's pouches are crammed to capacity the animal is obliged to unload by squeezing its face with its clenched fists.

The habit many creatures have acquired of collecting all kinds of objects which can be of no possible service to them is possibly a perverted outcome of this food storing. Rats have long been famous as secretors of bright objects, and a tame rat introduced to a heap of coins will almost certainly first select the silver for concealment in its lair.

Darwin has recounted how in America the natives when missing a revolver, belt, or other small piece of property, would first make search in the nearest viscacha warren, and there the lost property would almost certainly be found amongst the other heterogeneous objects gathered by the guinea-pig-like rodents.

COLLECTOR OF CARTRIDGES

Hoarding is rare amongst carnivores, but the northern wolverine or glutton, a large relative of the stoat, not only stores carcasses for future consumption, but if opportunity offers, collects coins, weapons and what not. Hundreds of cartridges have been found in a wolverine's retreat.

Amongst birds this quaint habit may have its springs in some dim æsthetic sense, for the raven and other members of the crow tribe share the bower bird's love of collecting bright or ornamental objects. Sometimes this may lead to quite a little human drama, as immortalized in the famous Ingoldsby Legend of the *Jackdaw of Rheims*, and in Dickens's delightful account of his pet ravens in the preface to *Barnaby Rudge*.

A few birds are genuine food hoarders, notably the butcher shrikes, which impale insects, small birds and even lizards upon thorns, with an eye to the demands of a hungry family. The little owl has been observed deliberately to kill small partridges and then revisit the corpses after they have attracted a hoard of carrion beetles, which the owl much prefers to game.

MONKEY'S TREASURE TROVE

Cecil Aldin, in his book *Dogs of Character*, recalls an instance of a monkey who collected not only reserves of food but dogs' teeth. The milk teeth shed by the artist's numerous puppies had an irresistible fascination for the monkey. He collected them as they appeared and stowed them secretly in a particular cranny by a chimney corner.

For weeks together he might apparently forget his treasure trove, but every now and then the urge to gloat over his hoard would come upon him. Then, creeping away with utmost stealth, he would unearth his museum, and ranging the teeth before him devour them with his eyes, as might a miser his gold. After a "session" of variable length, he would return his trinkets to their hiding-place, and then rejoin society, apparently much refreshed and in a condition of "uplift."



INGENIOUS WAYS OF CAPTURING PREY

(Left) Mata-mata terrapin with artificial worm. (Middle) Deep-sea angler, with rod, line, luminous bulb and hooks. (Right, top) Archer fish shooting fly with water. (Bottom) Ant-lion larva with pitfall for ants.

In the scattering of their waste products animals disseminate seeds, circulate and purge the soil, and perform many other useful services in distributing matter. Vast amounts of useful fertilizer, however, go to waste, as may be witnessed by the huge guano cliffs which stood for centuries on lonely islets until discovered and exploited by man.

VALUABLE WASTE PRODUCTS

The possible exhaustion of a soil's fertility is now beginning to draw serious attention to the utility of the waste products from food consumed by animals of all kinds. Through sheer wastage of sewage over two hundred thousand tons of phosphorus are annually lost to the United States alone, and this at a time when there is increasing need for the element, which is rare in a natural state.

In their manners and methods of obtaining food, many animals show considerable finesse, and this is often the more surprising when we find devices suggesting almost human dexterity in animals of relatively lowly origin. Mammals and birds tend to feed by very direct methods;

at most the obtaining of a meal implies an arduous chase or a certain degree of strategy in stalking. But in some fishes and reptiles the means of getting the next meal involves what can only be described as apparatus, of a complexity and delicacy quite disproportionate to its user's intelligence, which is generally of the lowest order.

TURTLE AS ANGLER

In Brazil there is an unlovely looking river turtle known as the mata-mata which literally angles for its prey. Whereas most predacious reptiles merely rely upon their resemblance to their surroundings, such as stranded logs, weedy stones, or mud banks, whereby to take the quarry by surprise, the mata-mata quite deliberately fishes for its dinner. On the creature's very deficient chin is a worm-like filament of skin which is gently waved in the water. Sooner or later a fish mistakes it for a worm, and such is the turtle's quickness of movement that the victim usually discovers its mistake too late.

Fishing for a living finds its highest expression

amongst the angler fishes, abundant in all seas and at all depths. The angler which comes to market as rock salmon is a typical fisherman of this order. The forward fin rays on its back and head are hinged so that they can be raised or depressed at will, and one or two of the longest bear skinny appendages very suggestive of small fishes. These lures, as they are called, seem to be used with some real understanding of their value, and once a fish bites, the angler's immense mouth plays the part of a very efficient landing net.

In the various deep-sea anglers the lure may be jointed, or dangled at the end of a sort of living fishing line. In the blackness of the abyss such a device might pass unnoticed, but it frequently bears a luminous bulb, so that the angler actually fishes as do many West

Indian fishermen, who cut out the light organs from certain fishes and impale them on hooks in place of the more conventional worm.

What we call sleep is most apparent in the vertebrates, and it varies enormously not only in species but in individuals.

The old adage, "Six hours for a man, seven for a woman, and eight for a fool," is not to be taken too literally. When some scores of celebrities were asked how much sleep they required, the results were surprising. Some of the best brains apparently needed but four hours' sleep in every twenty-four, others demanded twice as long.

BRAIN NEVER STOPS WORKING

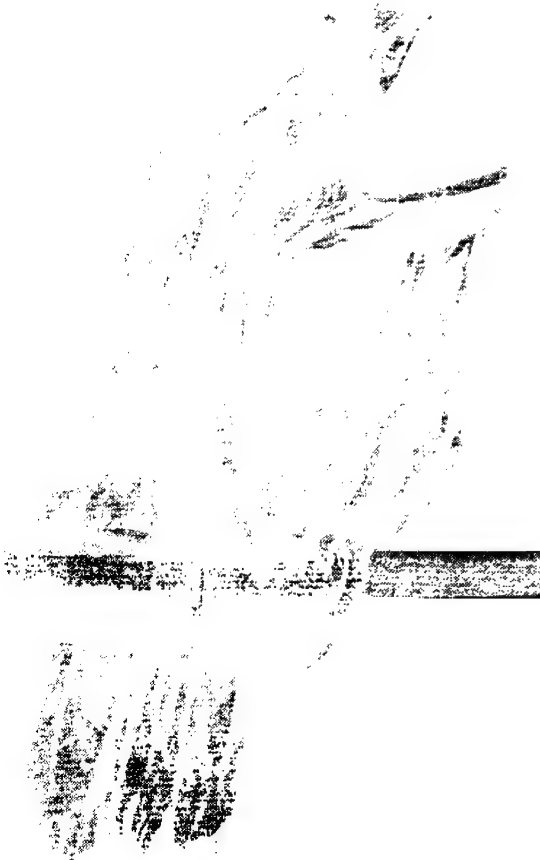
Marconi declared that quality of sleep was more important than quantity; Mr. H. G. Wells stated that eight hours was a minimum, and Mr. Henry Ford confessed that he slept six hours but was in bed nine. Napoleon would work for twenty-four hours without sign of fatigue, and seldom slept for more than two hours at a time.

Modern investigators such as Pavlov, have clearly demonstrated that though one is apparently quite unconscious even in so-called dreamless sleep, the brain never stops working altogether. The sensation of activity ebbs and flows in the brain continuously. We sleep chiefly at night simply because that is a convenient time. The work of many demands that they sleep during the day, and they do so readily enough. Similarly animals can be trained to reverse their normal hours for sleep, and they appear to suffer no more than any human worker on a night shift.

WHEN ANIMALS SLEEP

For this reason, a walk round a zoo at night is generally a somewhat disappointing experience. A high percentage of night prowlers are anything but prowling, since to do so would be purposeless. A few mammals, such as small lemurs, ant eaters and bats refuse to show themselves or feed until the last visitor has gone, but this is largely because, since they are not particularly good show beasts, no effort is made to exploit them. "The lions are fed at 4 p.m." proclaim zoo notices throughout the world, but this is a concession to a sensation-loving public, not to the lions.

Broadly speaking, mammals tend to sleep by day, birds by night. There are exceptions, and some of these rank amongst the profoundest slumberers. The night-flying birds



WORLD'S UGLIEST BIRD

WIDE WORLD

The frog-mouth, said to be the world's ugliest bird, sleeps so heavily that lifting it will not awaken it.



TRIGGER FISH

This long-faced fish has highly poisonous alkaline flesh, but probably some species find it edible.

known as frog-mouths, for example, sleep very heavily. No part of the brain seems to be in that semi-active state responsible for "sleeping with one eye open" as we say. A sleeping frog-mouth will suffer itself to be lifted from the branch, or even to have a companion next to it shot down, yet never show the slightest consciousness of anything untoward.

Sleep is a natural restorative of worn tissues and may come to the individual's aid when no means of refuelling the body machine is available. Intense cold or drought may both cut off food supplies for the time being, and the best way to tide over such lean times is to sleep. In the northern hemisphere many small mammals and all reptiles thus evade working extra hard for a living, as must such as elect to keep awake. The circulation falls and all the body machinery slows down, drawing what little fuel it needs from the fat accumulated in spring and summer.

ASLEEP FOR SIX MONTHS

The sleeping capacity of such creatures as the bear, hedgehog and dormouse seems to be much less than that of some desert animals. Many snails can sleep for half a year with ease, and there is one remarkable instance of a desert snail remaining quiescent for two and a half years in a museum case, at the end of which time it woke up, notified its presence by smearing slime on its exhibition label, and after being given a warm bath enjoyed a hearty meal.

The African lungfish digs itself into the river bed on the approach of the annual summer drought, and there remains within an earthen cell until the rains release it months later. For this reason, both lungfish and snails

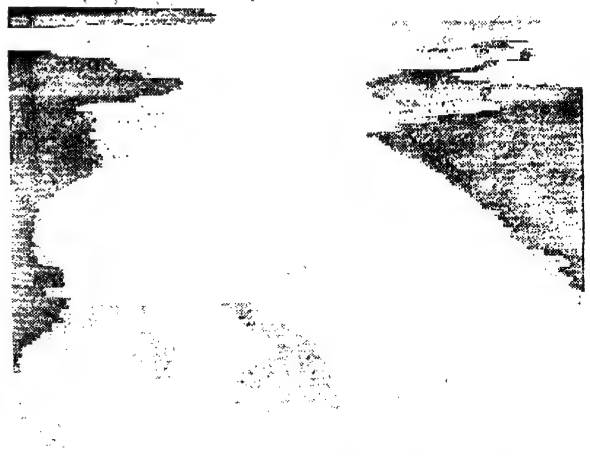
commend themselves to the natives as convenient iron rations, to be carried on long treks in inhospitable country.

Do fishes sleep? So far as recent observations in large aquaria cast light on the subject, most fishes remain in a dormant condition for some period in every twenty-four hours. Bottom feeding fishes such as dogfish and skate, sturgeon, lungfish, catfish and flat fish of all kinds are active at night, but by day usually lie half hidden in sand or mud.

A large number of other fishes are semi-dormant at night, resting amongst weeds, leaning against rocks, or lying motionless near the surface. The wrasses actually lie flat upon one side, almost like mammals. The various perches, breams, cichlids, trigger fishes and some kinds of trout rest on the floor. Sun-fishes, rock and sea bass, lean wearily against rocks, or perch amongst plants.

MULLETS' STRANGE BEHAVIOUR

Most striking of all is the behaviour of the grey mullet: as shown by experiments in aquaria, by day this fish moves steadily forwards in mid-water in solid shoal formation. At night the shoal is broken up; each fish rests horizontally on the tank floor, and each faces a different point of the compass. But the moment daylight is called up in the form of a powerful electric torch, or by switching on the lights above the tank, the fishes instantly come together again with almost military precision, all head the same way, and in a moment are off again upon their long trek.



W. S. BERRIDGE, F.Z.S. (MONDIALE)

FISH AND SLEEP

Most fish maintain a state of sleep-like immobility for a certain period during the day or the night.

THE ANIMAL KINGDOM

The young transparent fry, which hatch from eggs and mature very slowly, eventually make their way to the freshwater rivers, though perhaps thousands of miles have to be traversed. Doubtless, many millions of them fall prey to larger creatures.

For long enough the tiny specks of life which hatch from the eel's eggs were not recognized as having any connection with that fish, for the good and sufficient reason that none knew their source of origin. The larval form was therefore regarded as a separate and distinct species until 1896, when a scientist discovered in the Straits of Messina a series of specimens which revealed the truth.

AT THE MERCY OF OCEAN CURRENTS

The *leptocephali*, as they are called, are entirely at the mercy of the ocean currents. At the end of three years the fishes, now known as elvers, undergo a transformation which makes them more like an adult in appearance. Vast multitudes reach the shores of Europe and make their way up rivers, some even travelling overland in their urge to discover fresh water. The eels hibernate during the winter, and when they arrive at the age of puberty travel once again to the sea and the spawning ground two thousand or more miles away.

The story of Dr. Johannes Schmidt's researches since he discovered one of the larvæ near the surface some distance west of the bleak and desolate Faroes is one of the quiet romances of science that is not sufficiently spectacular to attract much attention. He followed his tiny clue all over the North Atlantic.

Perhaps the most remarkable fish in the world is the eel, which undergoes no fewer than eight changes in its life and seems to suffer from a perpetual wanderlust. In one of the phases it is a voracious feeder; in another it apparently ceases to eat at all for a time.

Dr. Johannes Schmidt, a Danish naturalist, found after extensive research lasting several years that the eels of both Europe and America journeyed thousands of miles to breed in the neighbourhood of Bermuda, where the Atlantic is deepest. He also discovered that the eels which frequented the rivers of East and South Africa, India, the Dutch East Indies and North Australia spawned in the Indian Ocean.

BRITISH MUSEUM (NATURAL HISTORY)

EEL'S DEVELOPMENT

Eight stages in the development of the eel. Note the reduction in depth and length during the change.



ONE OF THE PUFFER FISHES

WIDE WORLD

When it meets an enemy it blows itself out so as to make the short spines stand on end and present a very threatening appearance.



ANT CAMP FOLLOWERS

From left to right: A silver fish insect stealing food from honey pot ants; a mite riding on a soldier ant; beetles grooming the legs of an ant in exchange for food.

ANIMAL SOCIETY

FROM late spring to early autumn one often sees slow-running rivers or large tracts of stagnant water dyed a rusty brown, the mass coloration of uncountable legions of water fleas. Great areas of the sea are frequently discoloured in like manner by vast congregations of minute animals, and at night the waves appear to burn with a bluish fire. This also marks the presence of abundant life, that heterogeneous gathering of larval animals summed up in the word *plankton*, which is derived from the Greek *plagktos*, wandering.

Though all these gatherings of animals represent life as not even the most overcrowded city knows it, none of them can in the strict sense of the term be called societies. Society implies a certain co-operation and mutual tolerance, a coming-together for the general benefit, a quite selfish realization perhaps that No. 1 will stand more chance of prosperity in the proximity of No. 2 and No. 3, than if the individual remained in isolation.

By society one means a different gathering even from those immense periodic congresses of animals which occur during a breeding season, or when circumstances dictate a mass migration. Society implies a certain permanence, a lasting realization of the benefit to be derived from contact with one's fellows.

The water fleas, which dye the pond for yards around, are jammed side by side merely as the result of mass production. The scores of snails which one may rake out of some cranny during an autumnal clean-up in the back garden, are there, not from fellowship, but because the place appeals to each individual as an eligible spot for hibernation.

Animal society can be fairly sharply divided

into two categories, the complex civilizations of certain sociable insects, and the much more general love of society which can be traced right through the whole series of vertebrates, advancing in complexity as we ascend the scale, until we reach that mass of social, legislative and political machinery which has become essential to the bulk of mankind.

Many volumes have been already devoted to the social insects, and the reader will find a world of entertainment in the works of Tickner Edwards, Henri Fabre, Dr. Julian Huxley, and a dozen other writers of distinction. Here we can only roughly outline the civilization of the ants and termites, bees and wasps.

Before doing so let us warn the reader not to attempt to find in the lives of insects any parallel with those of human beings. Some authors have done so in all seriousness, to the detriment of science, and the obscuration of clear thinking. In another class are H. G. Wells's *First Men in the Moon*, and C. Capek's no less famous *Insect Play*. These are sharp-edged satires and are not intended as anything else.

The old tendency to humanize insects no doubt originated in the Eastern sage's exhortation to "go to the ant." Dickens dealt a shrewd blow at the false philosophy built up on that adage when in *Our Mutual Friend* he made the West-end lounge, Mr. Eugene Wrayburn, languidly protest:

"I object on principle, as a two-footed creature, to being constantly referred to insects. . . . For the whole case is assumed. Conceding for a moment that there is any analogy between a bee and a man in a shirt and trousers (which I deny), and that it is settled that the man is to learn from the bee (which I also



WATER FLEAS

Water fleas, which are lower crustaceans, in a pond jammed side by side as the result of mass production.

deny) the question still remains, what is he to learn? To imitate? Or to avoid? When your friends the bees worry themselves to that highly fluttered extent about their sovereign, and become perfectly distracted touching the slightest monarchical movement, are we men to learn the greatness of tuft hunting, or the littleness of the Court Circular? . . . Are human labourers to have no holidays because of the bees? And am I never to have change of air because the bees don't? . . . I think honey excellent at breakfast, but regarded in the light of my conventional schoolmaster and moralist, I protest against the tyrannical humbug of your friend the bee."

An insect of any kind is for all practical purposes a machine to do certain things, and none other, throughout life. In the social insects we find the society having its main springs in a queen, which is little more than an

egg-laying machine, and a number of males, one of which is destined to fertilize the eggs. Between these two are various grades of sexless creatures fitted, usually from the time they hatch, to perform certain functions, which however complex, however strikingly suggestive of human purpose and ingenuity, aim in the long run solely at the support of the living egg-factory—the queen.

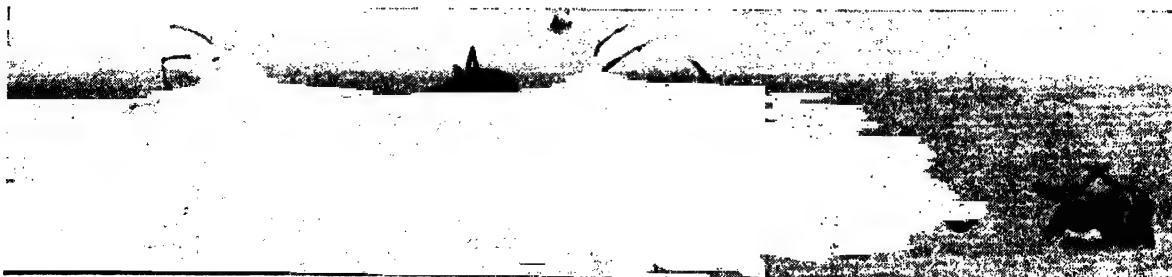
LESSONS SLOWLY LEARNED

One can no more hope to inspire an insect to cope with a sudden emergency, or adapt itself to swiftly changing circumstances, than expect a clothes-wringer to undertake a job of printing when the typewriter breaks down. Be it remembered that whereas a few centuries or much less may induce a mammal or a bird to bring about some changes in its ways of life, the insects had trudged on within their narrow grooves for possibly millions of years before the first mammals saw the light. Circumstances have planned the insects' programme, teaching them their little lessons by infinitely slow instalments.

ANT'S NUPTIAL FLIGHT

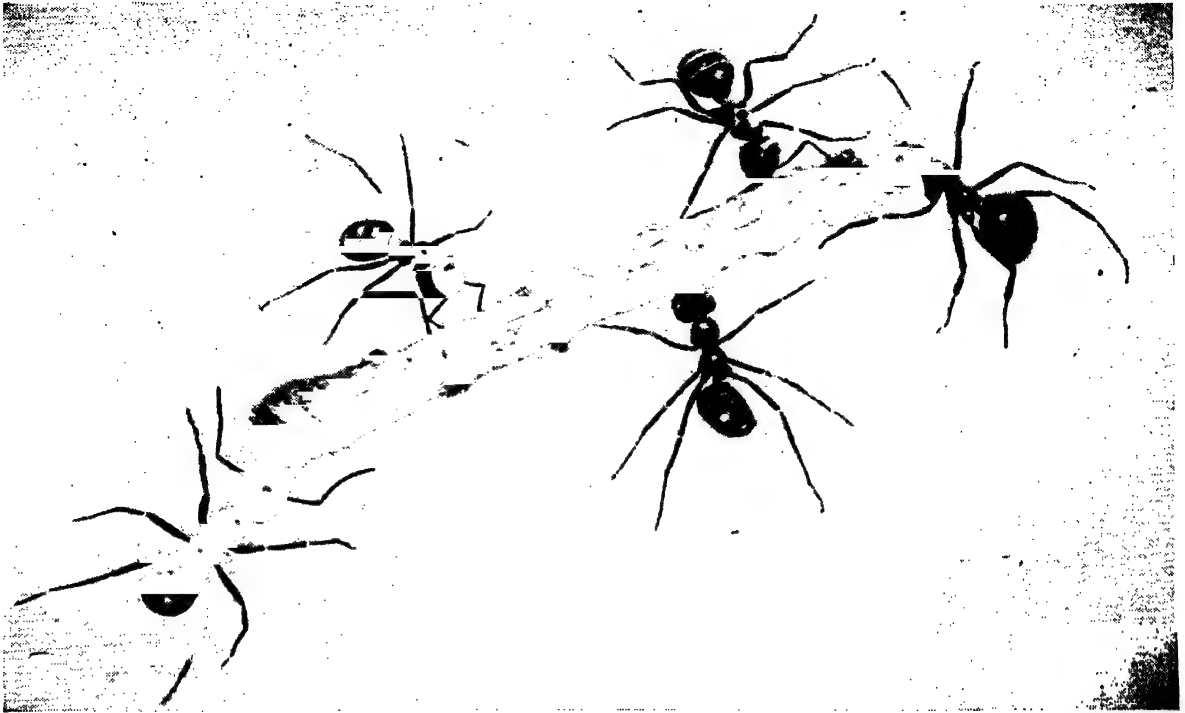
Ants present the greatest variety in their forms of society and modes of life of any social insects. Between three thousand and four thousand species of ants are scattered over the earth, reaching their maximum in size and numbers within the tropic belt.

In ants, as in bees and wasps, the female mates once only, during a "nuptial flight," and thenceforward settles down to lay eggs as required. The sperms with which she is impregnated during her brief matrimonial experience are stored within her, and passed on to fertilize the eggs in relays—over a period of perhaps nearly a score of years. The sex of an egg is determined by the number of



BATTLE OF THE ANTS

Left to right: At death grips; a casualty; sparring for an opening; the end of a struggle. Between three thousand and four thousand species of ants are scattered over the earth.



HAROLD BASTIN

ARDUOUS LABOUR IN THE ANT WORLD

Wood ant workers struggling with a twig to be used as building material. An ant community may number a few hundreds or scores of thousands according to the species.

sperms—or complete absence of sperms—allotted to it.

Ant communities are frequently subterranean, and all ants, once free of the chrysalis, should step on to the stage of life ready to work till they drop. A community may number a few hundreds or scores of thousands, according to the species. Infinite are the ways of the various communities.

ANTS AS FARMERS

The tropic battlement-ants build on steep hill-sides, and throw up concentric ridges or walls, which serve to divert water rushing downhill during storms, and so protect the nest from flooding. In striking contrast to the tortuous subways with which so many ants riddle flower beds are the homes of the leaf builder ants. One set of workers pulls the edges of two adjacent leaves together, whilst another cements them by squeezing an adhesive from ant grubs, using them as secretory tubes. Other tropic ants build nests of various materials on trees, causing the big outgrowths known as negro heads.

Amazing devices are resorted to for storing food. English gardens too often suffer from the cowboy ants which farm the destructive

aphis for the sake of the sweet secretion it exudes. Some foreign ants similarly farm various scale insects. The honey-pot ants use specially modified workers to retain huge stores of nectar within their abdomens, such ants becoming swollen to the bigness of peas. Even this is eclipsed by the mushroom farmer ants, who actually build fungus beds out of cut leaves, and sedulously cultivate vegetable moulds thereon.

Many readers have probably beguiled a summer afternoon in some woodland watching a party of slave-raider ants bearing off struggling victims from another tribe, later to train them to their own purposes, a bondage to which the witless captives raise no objection. For sheer aggressiveness, however, the raiders are quite outclassed by the terrible driver ants of tropical Africa.

MORE TERRIBLE THAN THE HUNS

These ants make foraging marches more terrible in their way than those of the ancient Huns. Everything falls before their serried ranks, and a regiment may take days to pass through a district. All kinds of insects, and even reptiles, small mammals and birds are devoured. A regiment consists of variously



MOST TERRIBLE OF ANTS

A winged male driver ant. Lions give the road to a contingent of these insects on the march.

graded individuals. So ne, known as soldiers, have enormous heads bearing razor-edged jaws. Even the lion and elephant give the road to a driver-ant contingent on the march.

Bees differ essentially from ants in that never more than one male fertilizes the queen, and the nest always consists of wax-built cells for the storage of eggs, grubs and food. This last is generally only nectar. Ants and wasps show a much wider range of comestibles, the former—according to species—favouring anything from corn to a dead horse.

Bee communities number only the queen, males or drones, and a single grade of worker, as against the various workers and soldiers of ant society. Further a bee society may range from the many thousands constituting a swarm to a mere family party, as in the bank-burrowing humble-bees.

COMMUNISTIC ANTS

Ants seem to hold together, to keep to their own sets largely by a sense of smell, but bees also evince a certain eye for colour, as is evident by the "honey-guide" markings on flower petals which lead them to the nectar. In large apiaries hives are coloured in groups, and this serves to keep the bees from wandering to neighbouring hives, and spreading disease.

An ant colony is communistic: the individual has literally no existence apart from the body corporate. Many kinds of bee, however, show considerable independence. Some few are quite solitary, lay their eggs, dump a certain quantity of food beside them and then leave them to shift for themselves. Bees have much higher intelligence on the whole than ants. They can be trained to couple a particular colour with a certain food, and with that only,

the knowledge remaining with them till they die.

Wasps show still more individuality. Nearly all build beautifully fashioned combs, deep underground or attached to tree branches and grass stems. The material used is not wax but paper made from chewed wood. A wasp is a little living paper mill. The sting which, as in the bee, is a development of the queen's egg-laying tool, is used not only for attack but often to paralyse insects, which can thus be kept in the nest, in cold storage, so to speak, till the wasp grubs are ready to devour them. It is largely a matter of chance as regards the effectiveness of the poison administered. Sometimes a caterpillar may be killed outright and decompose, or so slightly paralysed as to give the wasp grub some trouble when dinner time arrives.

EARTHWORKS OF THE TERMITES

The so-called white ants or termites belong to a tribe quite different from and more primitive than that of the ants, bees and wasps. Termites are purely tropic or sub-tropic insects, and they live underground. Their excavations may upraise huge earthworks, supporting large trees, but the real life of the community is deep below. As in ants there is an egg-laying queen and a male, but the neuters are either sterilized males or females, not as in ants of one sterilized sex only.

FOUNDING A COLONY

A white-ant colony is founded by a queen and a king, who meet on the wing, then descend below ground, shed their wings, build a nest and finally found a colony. As in ants, this consists of the same tireless workers and



HAROLD BASTIN

WORKER DRIVER ANTS

A regiment of driver ants consists of variously graded individuals. Everything falls before them.

nurses and formidable poison-squirting or scissor-toothed soldiers. But whereas the ants show great diversity of diet, the termites of whatever species know one menu only—wood. Human life in the tropics is one long battle against the insatiable appetite of the termites for anything made of wood, be it a clothes peg or a house.

Herein the termites are unique. Few creatures can digest hard wood—the beaver attacks only a tree's soft, sap-filled outer layer—but a termite digests tough wood fibre by means of innumerable protozoa (single-celled organisms) that swarm in its interior. Nowadays efforts are being made to protect all natural enemies of the termite such as birds, ant eaters and armadillos.

SCOURGE BUT NOT USELESS

Scourge though the termite is, this bleached and light-shunning dweller underground is of some economic use. Wood is not easily converted into fertilizer, but after treatment in the termite's strangely populated interior, it is broken down and returned to the earth for its replenishment and the ultimate benefit of plant life, and as a natural corollary, animal life also.

With that relatively enormous increase of



WORKER-BEE'S POCKET

Leg of the worker-bee, showing pollen pocket. Workers act as charwomen, nurses and food collectors.



HONEY GUIDES

HAROLD BASTIN

Honey guides on a violet. Bees often confine their attentions to one species of flower.

brain power which marks even the lower vertebrates, society takes on an entirely different meaning. A lobster can live sixteen years in solitary confinement in an aquarium, and provided it is well fed, never realize it is solitary. When we read of a spider saving a medieval prisoner's sanity merely by offering him companionship, it is well to remember that the spider would offer the benefits of its society just as readily to a musical box or a piccolo solo re-hered on a gramophone.

SOCIAL URGE IN VERTEBRATES

The vertebrates are in different case. Though fish will live many years in isolation, it is noticeable that most do better if given the society of their own kind, and this is particularly apparent in the many hundreds of shoaling species. If a herring is introduced into a tank which has hitherto housed but a single herring, the two fishes meet, and are very soon both heading the same way, side by side. If a shark plunges into the centre of a shoal, or the shoal leaders suddenly come in contact with a cliff face or other obstruction, there is temporary confusion. But before long, the shoal will have surmounted or circumnavigated the obstacle, and so proceed on its orderly way.

The extent to which even the many kinds of herding reptiles are really appreciative of each other's society, and not merely brought together by mass production or the mutual appreciation of common feeding grounds still

needs further investigation. But amongst the birds and the even more highly constituted mammals, society is a very real thing, quite apart from the periodic meetings occasioned by courtship.

To many birds and still more mammals, solitary confinement is almost the worst cruelty that can be inflicted on them. So great is the social urge that a bird or beast denied the comradeship of its own species, will often go to extraordinary lengths to find a substitute. The newspapers frequently bring to our notice a strange friendship, as between a goose and a cat, and a dog and a badger. Zoos are full of queer partnerships. Apes and monkeys will joyfully accept almost any kind of cage-mate rather than none.



BUILT BY TERMITES

Termites, often called white ants, build homes which may reach a height of twenty-five feet.

Quite recently London's Zoo could show a green monkey fast friends with a wombat, and a young orang inseparable from a tree kangaroo. In the old days, when all the Zoo's service traffic was equine, an old horse which hauled the fodder cart could not be induced to proceed with the day's work until he had had his morning "chat" with a reindeer. Another horse similarly never failed to pass the time of day with a zebra. A famous zoo lion spent his cubhood in the society of a hutch full of rabbits. These instances of the social urge might be continued almost indefinitely.

ANIMAL DICTATORS

The flocking instinct of birds seems to have more in common with the communistic shoaling or schooling of fish than the gregariousness of mammals. Birds certainly derive great benefit from mass formation since the whole of a flock seldom sleeps simultaneously. Hence there are always some members in various degrees of wakefulness, and so able to give warning of approaching danger, though modern observers tend to doubt the old stories of deliberately posted sentinels.

Among mammals we have the first crude foreshadowings of councils, watch committees, government, and sometimes even of dictatorship. Most of the hoofed animals go either in small parties or great communities under the dominance of a leader and a number of aides-de-camp, one or more of which sooner or later evinces aspirations towards command. One may trace the parallel to much higher society without strain or undue humanizing.

In the pack and the herd there are command and intrigue—and co-operation. An old dog-wolf and a handful of seniors lead the whole pack in crescent formation towards a herd of musk oxen or deer. The grazers retaliate by bunching cows and calves together, the bulls forming a wall around them, and with heads down and horns at the ready, prepare for the attack.

BATTLE CODE OF SHEEP

Sheep, particularly wild sheep, have a well-established battle code. If only a solitary dog, of any size, threatens the lambs, they, together with the ewes, go to the rear. The rams then advance in succeeding ranks, those composed of seniors being to the fore. Thus arranged, the whole contingent slowly advances, and as the rams go to meet the foe they stamp with their forefeet—in unison. The effect can be highly



GANNETS PROVE THE FLOCKING INSTINCT

FOX

Gannets nesting on the island of Grassholme, off the Welsh coast. Birds derive benefit from mass formation since the whole of a flock seldom sleeps at the same time. The female gannet is careful of its eggs and will sit on its nest and defy anyone who dares to approach.

dramatic, and if the dog lacks the moral support of an accomplice he almost invariably decides to leave the flock in possession of the field.

REVELRIES OF CHIMPANZEES

Dr. Zuckermann, in his exhaustive study of monkey society, did not find a single instance of apes or monkeys living in anything but a social state, which might vary from a family party to a troop of some hundreds strong, the troop in its turn comprising a large number of family gatherings and cliques. The baboo notorious as social monkeys, offer a striking instance of the strength that lies in numbers. The enemy of one automatically becomes the enemy of all. Many authentic stories are told of young or crippled baboons being left behind during a retreat, but only temporarily. Invariably a number of elders turn back, and by their ferocious demeanour hold the pursuers in check whilst the laggard regains the main body.

The chimpanzees, highest of all the lower primates, are even more strikingly human in

their social traits. They recognize not only large family groups, or aggregations of family groups, but also a kind of club life. Chimpanzees emancipated from the nursery, but not yet arrived at maturity, form unruly mobs which racket through the jungle, enjoying themselves at the general expense. The hooligan revelries of one of these "mixed clubs" leave a trail of devastation and disgruntled would-be slumberers in its train, and it may so happen that the ringleader of one of these parties is a purposeful member of the gentler sex.

BREEDING STORMS

The rollicking, nomadic bands of adolescent chimpanzees naturally suggest one of the most striking aspects of animal society, namely migration. It has been already pointed out that vast periodic migrations may be inspired by the mating instinct, as in the march of the land crabs across great tracts of Africa, or the strange tree-top congresses of Brazilian sloths.

But migration, as with the nomadic American Indians or the wandering Hausas of the Sudan, may also be the result of hunger or disease. Astonishing tales of undoubted authenticity are told concerning the migrations of some hoofed animals in the days before the advent of the high velocity rifle.

There was a time when, as winter approached,



TOPICAL

FOX FIGHTER OF MOUSE PLAGUE

On an Australian farm seventy thousand mice were destroyed in a few hours by owls, foxes and ferrets.

the Canadian caribou passed to their cold-weather quarters in an unbroken procession, streaming through a district for several days on end. Less than a century ago, the South African springbok antelope migrated in such uncountable numbers that the very veldt seemed to move, as did the forest in *Macbeth*, and a lion caught in the close-locked ranks had no choice but to march with them until new grazing grounds were reached, and open order became once more possible.

A veracious tale is told of the big snub-nosed monkeys of mountainous China, migrating from one range to another. Entire villages turned out, spell-bound, to watch the march-past. Public enthusiasm at last caused the monkeys to stampede. They left behind them various jars of home-made wine which had been tightly clasped to the dense fur of their bellies—the said wine having been mourned as missing from a neighbouring hamlet for many months.

These regulated seasonal migrations usually have a happy ending. The promised land, hoped for by the leaders, is reached at last. But there are other less regular migrations occasioned by overcrowding, and then disaster follows. All animals are liable to what scientists call breeding storms.

Multiplication, unchecked by natural influences, reaches a climax, and there results a vast hunger march. The plagues of Egypt have been repeated with variations many times the world over. In 1907 three-quarters of Nevada's alfalfa crop were wiped out by mice, the burrows of which made the country look like a great sieve.

OVERCROWDING BRINGS DISEASE

Ten years later such a mouse plague swept a large area of Australia, and on one farm alone seventy thousand mice were destroyed in a few hours. Owls, foxes and ferrets gorged to repletion, without making any appreciable impression on the flood of rodents. None can doubt that the legends of the Pied Piper and the Wicked Bishop in the Rhine tower have their roots in fact.

In medieval times the Church was not infrequently called in to exorcise the animals causing a plague, and when the pests happened to be rodents the horde made for the sea and were drowned. The apparent miracle thus performed really had a simple, natural explanation. Unchecked breeding means overcrowding, and sooner or later overcrowding inevitably spells migration and disease.

This is how the periodic lemming plagues of Scandinavia always end. One such occurred only a few years ago, and it so far upset what is loosely and misleadingly called the balance of Nature that repercussions of the plague were felt as far south as Yorkshire.

NATURE'S UNSTABLE BALANCE

The little rodents known as lemmings form a staple diet of the Arctic owl. The owls, together with foxes, lived riotously on the lemming hordes making blindly for the coast. When, finally, the lemmings met a watery end, the foxes, more resourceful than the owls perhaps, and in any case unable to proceed farther, turned back to live as best they could. The owls, however, embarked in sheer desperation on a hunger flight. Some perished, no doubt, some made the Scottish peaks or Yorkshire coast, and some few, sinking exhausted

upon the decks of chance vessels, eventually gravitated to zoological collections.

Animal society, indeed, is not so very far removed in its essentials from our own. The same motives inspire the bower birds' assembly hut and the dance music which the B.B.C. retails. There is much in common with the march of the caribou and the posters offering "special facilities to intending colonists" displayed in our shipping offices. When animal and human conceptions of an ideal state come into conflict then the complexities of Nature's most unstable balance are increased a hundred-fold.

There is no need to insist upon the interdependence of animals, but dependence is a matter of degree, and some kinds of dependence are more intimate than others. In olden times any animal obviously deriving some benefit from another was dubbed a parasite, but modern naturalists now make fine distinctions between the many animal associations and partnerships.

PARASITIC GATE-CRASHERS

In parasitism pure and simple the benefit is entirely one-sided, the guest being in the nature of a gate-crasher, and giving nothing in return for whatever it may gain from its host. Often an apparent parasite and its host are really messmates. Such cases are now placed in subdivisions according to the precise nature of the partnership.

Symbiosis (from *syn* together and *bios* life) describes any two creatures living in unison for mutual benefit. Inquilism is a more recent addition to scientific language, borrowed from the Italian *inquilinus*, a lodger who comes and goes at will without paying rent. Commensalism implies animals sharing a common table, and in some way describes a certain modern ideal of human society, though not an ideal necessarily finding universal acceptance.

WORRIES OF THE MARMOT

Very often an animal partnership is not easily classified correctly at a cursory glance. A classic example of this kind is offered by the prairie marmot, a little guinea-pig-like rodent living in large communities on the plains of North America. This busy little rodent drives long and deep burrows in the sun-baked soil, and in a land where enemies are many and cover scarce such subways offer ideal homes to animals less industrious or unformed by Nature for such navy work.

The marmot is soon honoured by callers, the

rattlesnake and burrowing owl. Victorian school-readers and popular natural history books used to paint a charming picture of this colonial life. It was invariably represented as a sort of Utopian commonwealth, a Wild West paradise. Bird and reptile were presented as friends and playmates of the paunchy marmot. Closer observation has revealed the sordid truth. Rattlesnake and owl vary their menus



DR. GRAF ZEDTOWITZ (MONDIALE)

ARCTIC OWL

Sworn foe--with foxes--of lemmings, of which there are periodic plagues in Scandinavia.

by eating each other's young, and those of the marmot.

The wretched rodent has no sort of redress or means of retaliation. Sooner or later it is forced to effect a moonlight flit from its hard-won home and dig elsewhere. A few days or weeks of peace may follow, but sooner or later the marmot returns from foraging only to find its self-advertised lodgings let on an indefinite lease.

In the northern coastal areas of Great Britain the rabbit knows something of the marmot's worries. The sheld duck finds its

burrow a perfect home for her own youngsters, and so does the puffin. But whereas the shield duck flies in to leave no tell-tale footprints and brings up her young in some secluded by-way, the puffin shows no such finesse. It often kills off the young rabbits to make room for its own. Winter may find the moorhen also sheltering in a rabbit's bower, but no rudeness is intended, and the bird just waits in the passage till the weather breaks.

Birds often billet themselves on larger creatures. Some species build in the matrix or outskirts of larger nests, whilst many kinds haunt big animals, and for ridding them of insect pests are entertained most willingly. Little snowy cattle egrets ride on bison and other big game and dig out ox-warbles and other horrors.

ADAPTABILITY TO CIRCUMSTANCES

It is interesting to recall that Captain W. P. Beale was the first to agitate for the organized protection of these little birds in the Sudan. When as a veterinary surgeon he was brought in daily contact with the wandering Hausa tribe of that region, he noticed how the egrets followed the flocks and herds up and down the hundreds of sun-scorched miles between water

hole and water hole. To this day cattle egrets of the Sudan are spoken of by the natives as "Doketar Billie's Pigeons."

The cattle egret is a heron and should feed on fish, but frequent fish famines have converted it to largely an insect diet, an interesting case of adaptability and bowing to circumstances.

BIRD JOCKEY OF THE RHINOCEROS

The ox-pecker, rhinoceros bird, or African starling, lives on similar lines. It rides nonchalantly on the big two-horned rhinoceros, in which act the cave-man first noticed and depicted it. Its cool impudence and daring is only surpassed by the little plover-like crocodile-bird or courser of India. It serenely scuttles in and out of the open mouths of giant man-eaters as they lie basking on the mud flats, and picks scraps of past meals from between the teeth, besides removing leeches and other nuisances from the monster's jaws.

Some remarkable gate-crashers occur amongst fishes. Round the coasts of Great Britain in fine weather one may meet floating far out at sea large jelly-fish, two feet or more across. Beneath the "umbrella" of the jelly-fish hides a shoal of baby horse-mackerel securely hidden from the hungry eyes of gulls above and protected by



BARTLETT EXPEDITION TO THE ARCTIC (WIDE WORLD)

WANDERER IN ARCTIC WASTES

Once a rover in Europe and America, the musk-ox is now confined to the Arctic regions of North America. The animals live in herds, and are an important item of diet with the Eskimos.



LITTLE BIRD FRIEND OF A BIG BEAST

A cattle egret perched on a hippopotamus, although it also rides on other big animals. It scavenges for parasites, and thus performs a good deed for the unwieldy beast.

the accommodating stinging cells from foes in the surrounding water. That they sustain no injury from the jelly-fish is surprising.

MORE DREADED THAN THE SHARK

Yet their case is no more wonderful than that of some other fishes patronizing equally or more deadly relatives of the jelly-fish. In tropic seas lives a little fish that actually hides amongst the stinging cells of the Portuguese man-o'-war, a jelly-fish dreaded by sponge fishers even more than is the shark.

In a similar class we may put the gorgeous little coral fishes of the Netherlands Indies. These fishes hide within the body cavity of a huge sea anemone, two feet in diameter. Immune, they play amid its thousands of stinging tentacles, retiring deep into its interior on the least sign of danger. Perhaps their tough scales protect them from harm, though this is hard to believe because most small fishes easily succumb to giant anemones. The coral fishes share their home with a certain prawn, and both fishes and crustacean perfectly blend with the gorgeous colouring of their strange host.

Other instances of fish gate-crashers are

small fishes living inside sea cucumbers and starfish, giant whelks and even the gill chambers of other fish. In return quite small fishes may themselves become hosts. Certain little tropical fishes carry on their bodies or spines colonies of hydroids—tree-like creatures allied to the coral animals. Here there is mutual benefit, for the hydroids are carried continuously to fresh feeding grounds, whilst their presence makes the fish an undesirable mouthful to creatures that would otherwise devour it.

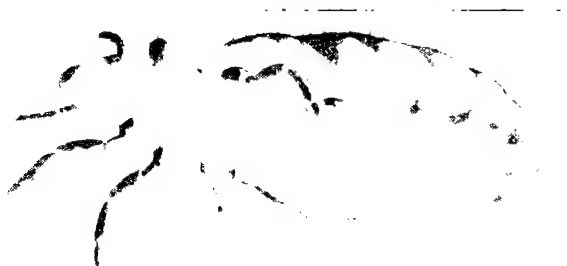
HANGER-ON TO SHIPS

We have all read old stories of the wonderful pilot fish that befriends the shark, and whilst gratefully eating such crumbs as fall from the big fish's table, guide it to likely game and warn it of foes. The sagacity of the pilot fish has been in question now for some time. It shows little nicety of taste, and when no shark is available, will follow a ship and gulp down offal flung from the galley. Once two pilot fishes came thus into Falmouth harbour having accompanied a vessel for nearly three months.

The most famous of all fish gate-crashers and camp-followers is the classic remora or

sucker fish. Somewhat resembling a mackerel in shape, it is a foot or two in length, with the dorsal fin converted into an immense sucking disc by which it adheres with extraordinary tenacity to anything it touches. Forcible detachment is only possible by a sliding movement. The fish will act as a hanger-on to shark, turtle, ship, indeed any large moving object.

Early naturalists, from Columbus's day onwards, made wonderful pictures of the fish, based on "eye-witness accounts," hauling whales and sea lions out of the water. More



PARASITIC INSECT

WIDE WORLD

Lice are parasitic upon man and other animals, few of which are wholly free from pests.

wonderful is the fact that West Indian fishermen still use the fish, as in remote antiquity. They tether it to a long line and then launch it at a turtle basking on the sea surface. The sucker or fisherman fish automatically holds on to the turtle, and both are easily hauled aboard. The shark sucker usually affixes itself to the back or belly of the temporary host, but when billeting itself upon a particularly large shark may even take up a position on the roof of the monster's mouth.

ANCHORAGES FOR BARNACLES

Apart from the crocodile-birds already noticed, neither reptiles nor batrachians seem to offer many attractions to parasites. Marine turtles may be burdened with barnacles and other hangers-on, but merely because they offer convenient anchorages, as do harbour piles and ships' keels. Land tortoises, on the other hand, are much burdened with ticks, and even the little garden tortoise often harbours specimens as large as one's finger nail, clinging tightly to the reptile's rugose skin by means of their eight sharply hooked legs.

Fish are afflicted by immense numbers of parasites of all kinds. Flukes and other worms infest the gills, leeches tap the blood stream at

all points, enormous lice, often half as big as the host, similarly drain a fish's energies. The common skate often comes to market bearing big green leeches some six inches in length.

A strange parallel is offered to the leech in the lamprey, once an important food item in Great Britain prior to the wholesale pollution of rivers by waste products from factories. The lamprey, with its tubular mouth ringed with scores of horny teeth, eats into the flesh of a fish such as a salmon, until it taps a vein, when it drinks its fill, usually causing the death of its unwilling entertainer.

Few animals are wholly free from pests of one kind or another. The horny-skinned starfish and the even more effectively armoured sea urchins are sometimes bothered by a small sea snail, known as *astericola*, that lives amongst their spines. The crab, well protected though it is, often falls victim to an insidious foe, which may be found fixed tightly to its under surface.

PRICE OF PARASITISM

The parasite when thus attached appears as a shapeless bag of tough skin, about as big as one's thumb nail. It offers a remarkable instance of degeneration for it is actually a barnacle, and when quite young is almost identical with the free-swimming, hard-shelled larvæ of the common acorn and goose barnacles. But when the time comes for it to settle down it does so upon a crab, and there, casting aside its armour for the last time, becomes little more than a stomach, sending threads into every portion of the crab's anatomy, and by these countless arteries deriving its sole source of nutriment.

It pays the price of all true parasitism in becoming more or less helpless, and finally exhausts its sole means of sustenance, for the crab, once attacked by *sacculina*, as the parasite is called, usually dies a premature death.

There is frequently found within the edible mussel a small crab, known as the pea crab, being not unlike a pea both in size and form. The crab is merely a messmate, and in America, where a larger species invades the oyster, it is even more prized than the bivalve. The female pea crab has feeble legs and is so helpless that she spends her whole life hiding within the mussel, this sheltered life having tended to soften her shell, and so render exposure to the world without inadvisable.

The male pea crab, though only half the size of his mate, is a much more vigorous



FISH PARTNERSHIPS

1 Coral fish of the Great Barrier Reef living in a giant anemone ; a little fish that hides amongst the stinging cells of the Portuguese man-o'-war ; Mediterranean fish living in a sea-cucumber.

creature, having a hard shell and serviceable legs and claws. He leads a roving, independent life, only at mating time visiting mussel after mussel in search of a partner. Having found a suspected shell fish he patiently waits until its shells gape, when he deftly sidles between their sharp edges and joins the female.

It is doubtful as to whether the mussel derives any special benefit from the crab's presence, but many other marine animals find in crabs very harmonious and profitable collaboration.

ANEMONES AS TONGS

A tropic crab carries one or two anemones in each claw, and uses them as living tools whereby to obtain food and also to ward off enemies. The crab, of course, purloins much of the anemones' hard-won victuals, but the anemones, by being carried from place to place, derive undoubted benefit in commanding a wider range of hunting grounds than they would if anchored to one spot.

The lodgers which billet themselves on the common hermit crab were glanced at in the chapter on Home Building. It may here be

pointed out that only the marine hermit crabs appear to be thus imposed upon. There is a noticeable absence of lodgers on the shells worn by the big tropic hermit crabs, who live largely on land and even scale cliff faces or go birds' nesting.

ANTS' NIGHTMARE WORLD

Semi-parasitism, both in human and animal society, reaches its maximum development in the large community. The lighthouse keeper and the little island community are practically immune from footpads, burglars, begging-letter writers, bogus company floaters, and all the other pests which permeate every grade and stratum of the human metropolis. Moralists the world over never tire of pointing parallels between human civilization and that of the social insects. As already mentioned, such parallels are superficial or based on faulty observation, but at least human and ant society groan together beneath a common curse in the enforced support of blood-suckers.

As a chosen victim of the unscrupulous adventurer, both the bee and the wasp are outclassed

by the thrifty ant. As with ourselves, the very vastness and complexity of an ant community offers ideal conditions to the smash-and-grab ruffian, or the more insidious purloiner of the society's garnered wealth.

About four thousand different kinds of ants are known, and upon these batten some two thousand kinds of insects, mites, spiders and crustaceans. Some of these gate-crashers are got up to resemble their hosts, and so largely escape detection; others enjoy immunity from arrest—and execution—by sheer nimbleness of foot, others again achieve their own ends by



HAROLD BASTIN

ANTS AS FARMERS

Green fly are farmed by ants, who greatly appreciate the syrupy exudations of the aphides.

blandishment, caressing and petting the ants, or even pandering to the worker ant's insatiable appetite for sweet things.

It is this which has led the green fly or aphid to be so extensively farmed by ants, who find in the syrupy exudations of the aphid an ambrosia of which they never tire. It is a nightmare world on which we look, when probing the secrets of the ant community. As Dr. Julian Huxley has well expressed it:

"If we imagined that in England our houses were, against our wills, inhabited by cockroaches as big as wolves and house flies like hens, and that there were crickets to whose presence we were indifferent, although they were the size of our own children . . . and monstrous creatures which we allowed to eat our babies in their cots because they secreted hot rum

punch or some equally fascinating liquid . . . then we should begin to get some idea of the ant's menagerie of guest animals.

"Apart from the aphid, or 'ant's cow' as it has been called, about two hundred kinds of beetle offer sweetmeats to the ant—in exchange for the privilege of eating the ants' babies unchallenged."

GLANDULAR ATTRACTIONS

Professor Wheeler, in *Social Life Among the Insects*, has said of these interlopers: "Any insect possessed of these glandular attractions can induce the ants to adopt, feed and care for it, and thus become a member of the colony, just as an attractive and well-behaved foreigner can secure naturalization and nourishment in any human community. But the procedure among the ants is more striking, because the foreigners are so very foreign. . . . Were we to behave in an analogous manner we should live in a truly Alice-in-Wonderland society. We should delight in keeping porcupines, alligators, lobsters in our homes, insist on their sitting down to table with us, and (in some cases) feed them so solicitously that our children would either perish of neglect or grow up as hopeless rachitics."

This catering for the ant and systematic cultivating of its demoralization—for the ant's rapacity for sweetness is like the drunkard's lust for alcohol—finds its highest, or lowest, expression in a little beetle known as *lomechusa*. It supplies sweetstuff to the belligerent red slave-maker ant, and even the beetle's grub is a sort of perambulating bar.

DRONE FLY SCAVENGERS

Another beetle, *oxysoma*, takes its fill from the ant's store cupboard after having stroked and wheedled the ant into a sort of coma. This is a favourite trick with many ant guests, and is an imitation of the stroking of one worker ant by another when it wishes it to regurgitate food. Half a dozen *oxysoma* beetles may thus combine to coax an ant into giving them a dinner.

Cruder but bolder are the tactics of the silver fish insect, a creature which sometimes invades our larders. It waits until one ant is passing food to another and then, neatly intercepting the titbit, makes off at high speed in the most approved bag-snatcher manner. Only recently the larva of the large blue butterfly has been added to the list of ants' guests.

White ants, or termites, bees, wasps—all the



SILVER FISH INSECT

HAROLD BASTIN

This little creature snatches food when one ant is passing it to another and then makes off at high speed.

social insects, in fact—are thus to a greater or lesser degree victimized. Sometimes a nest-crasher is tolerated for genuine benefits conferred—as distinguished from gifts of sweetmeat offered as a cloak to mass murder of the host's progeny.

Some of the drone flies of Great Britain got up very like wasps and enter wasp nests unchallenged, wherein they lay their eggs. These hatch into spiny grubs that assiduously eat up the dirt often encrusting the crowded cells of the comb, and even eat up the dejecta on the midden below the nest. The wasps seem well aware of the service rendered, for both fly and grub are treated with respect.

A less desirable lodger of the wasp is a little beetle known by no more popular name than *Rhipiphorus paradoxus*. The grub of this beetle has a sucker at the hinder end of its body, and with this it anchors itself to the top of a wooden post, and there waits until a wasp arrives in search of nest-building material. The beetle grub, reared up on end with its legs waving in the air, climbs on the back of the first wasp that appears, and in due course is carried to the nest.

WASP'S RELENTLESS ENEMY

Safely arrived at the nest, the beetle larva eats its way into the creature's interior until too large to find such cramped quarters comfortable, when it regains the open, plugging the hole in its victim's side with its own cast skin. The wasp grub still lives, and although the beetle larva continues to feast upon it, now from the exterior, enough vitality is permitted to remain in order to allow the luckless grub to spin its cocoon. The beetle's offspring then gobbles up the last of its host and lies snug in the ready-made cradle of silk until it turns into a chrysalis, and finally emerges as a perfect beetle.

This, to us, seemingly fiendish artifice is a variant of the ichneumon fly procedure, wherein

the fly's egg is deposited in a living caterpillar and there metamorphoses, eventually creeping forth as a fly from the moth or butterfly chrysalis. We shall see later how, during the last few decades, man has learned to turn some of these insect parasites to his own advantage.

PLAYING TIT-FOR-TAT

Occasionally, there occur instances in which one animal makes use of another and is in return utilized without either party being conscious of deliberately playing tit-for-tat. In the fresh waters of Europe lives a small fish known as the bitterling. When the time comes for the fish to deposit its eggs, the female does so by inserting a long ovipositor—literally an egg gun—into the inhalant siphon of a freshwater mussel, and the eggs being carried into the mollusc's gill chamber there remain secure from foes until hatched.

Here the fish appears to be making use of the mussel in a very one-sided manner, but in due season the mollusc plays a return match. Its young, like those of most molluscs, are minute organisms swimming by means of hairs. But in the freshwater mussel the two shells of the larva have each a strong hook, and the infant shell fish is further prepared for its peculiar start in life by means of one long sticky thread which floats loosely in the water. It may thus stay indefinitely until it dies, but all going well, in time there passes by a shoal of fish, as likely as not a bitterling. By the convulsive opening



HAROLD BASTIN

ICHNEUMON FLY

Its egg is deposited in a living caterpillar such as that of the large white butterfly.

and shutting of its two shells the little mussel forces the thread upwards and, fortune favouring, it sticks into a passing fish.

For a while the shell fish, now launched, may be trailed behind, but soon it comes in contact with the fish, and then the hooks grip the skin, and this in time grows up around the little glassy shells. Here it stays, as secure as may have done its host before it in its own parent, and some three months later bursts through the



ANIMAL FRIENDSHIP

A chimpanzee at a zoological garden which took as its boon companion a tabby cat.

tightly stretched wall of its travelling home, to live its life out as a mussel driving a lonely furrow in the river bed.

As we descend the scale of life parasitism assumes more sinister forms, since the often minute size of the parasite renders its presence undetected until its ravages have passed beyond checking. The legions of the mites and ticks, those Lilliputian cousins of the spiders, inflict themselves upon every branch of the animal and vegetable kingdoms in innumerable ways.

They may be relatively harmless, petty polluters of foodstuffs, like the tiny mites which often swarm in flour or very matured cheese. Others, like the itch mite, find themselves in a sheep's bile duct, and having climbed up it into the liver banquet there some six weeks,

eventually depositing eggs. So this strange history turns full cycle, launching another swarm of flukes upon the world and spelling ruin to the farmer.

ENEMIES OF MAN

The study of parasitic worms, or helminthology as it is called, now ranks amongst the most important of all branches of medical research. The study not only tracks down, and sometimes remedies, matters inimical to human welfare, but incidentally shows up many animals in a quite new and hitherto unsuspected light. Thus all kinds of browsing and grazing animals, numerous snails, insects and river crabs, though harmless or even useful in themselves, may under certain circumstances prove deadly foes by harbouring flukes in various stages of development.

A tropic fluke conveys via a small marsh snail the disease known as bilharziasis, in which the spiny eggs of the fluke perforate the human bladder and intestine. Allied to the flukes are the tapeworms, each segment of whose bodies can release myriads of eggs that being expelled with the faeces, carry on the race at the expense of man or beast. Often a tapeworm enters the human system via a meal of meat, the intermediary stages of the worm being spent imbedded in the muscles of an ox or a pig.

That most repellent ailment, elephantiasis, which may distort the affected areas of its victim almost beyond recognition, is due to a minute round worm, one of a too numerous clan known as the filaria. Another may infest man's muscles, being relayed via the muscles of the pig—a telling argument in favour of well-cooked meat.

VERMIN ERADICATORS

One might continue to review this rogues' gallery of the parasitic worms almost indefinitely, for the study is still in its infancy, but enough has been said to give some conception of its wide scope and ramifications. We will close this glimpse of animal partnerships and interactions with a prettier picture.

As already stated the more obvious partnerships amongst highly-constituted animals are relatively rare. Fox and badger sometimes share an underground flat, reptiles and birds the same burrow, or large beasts may tolerate small ones for their offices as "vermin eradicators," as up-to-date rat catchers call themselves.



AMERICAN MUSEUM OF NATURAL HISTORY (WIDE WORLD)

EVER ALERT FOR POSSIBLE ENEMIES

Vigilance is the price of life. The tense alertness which the jungle creatures must always keep is evident in this group of Indian bison, which is without the hump of the American species.

But none of these can compare with the ministrations of the little tropic birds known as honey guides. Here, once again, the victim is the long-suffering bee.

BIRD AND BADGER

Honey guides are dingy little birds, allied to the woodpecker and found chiefly in Africa, though one is recorded from the Himalayas and another from Malaya. Science has called one genus "indicator." A typical honey guide is the mayimba of Northern Rhodesia. Like the rest of its class, the mayimba feeds almost exclusively on the grubs of bees and wasps. It is no better provided than the average small bird for an attack upon a mob of several thousand furious bees, but it overcomes difficulties in its way by an extraordinary capacity for coupling cause with effect. It finds a partner to do the dirty work.

Usually this partner, in Rhodesia, is a small badger, whose capacity for hive-breaking has so won native respect as to cause him to be usually spoken of as Mr. Kambole. Kambole is a glutton for honey, but his legs are very short, and ill-suited for long treks from hive to hive. So he waits quietly until mayimba

arrives, in great excitement, fluttering about his head and uttering shrill cries. Kambole bestirs himself and ambles off in the wake of the bird. The trek may be long and arduous, but the badger persists. He has never known the bird to let him down. It may also happen that some wily native notes the badger's businesslike progress and follows at a distance.

Before long the bees' nest, some distance up a tree bole perhaps, is reached. The badger, confident in his sting-proof hide and coat of coarse hair, attacks, and the bird feasts as the luckless larvæ are tumbled pell-mell into the open. The bird continues to gorge long after the badger, replete with honey, sinks to sleep amongst the havoc he has caused.

INTOXICATED ON HONEY

The partnership, like all other combines, has its ups and downs. Sometimes the bird leads the badger to one of the crude home-made bark hives erected by the natives, but reprisals are seldom if ever taken. The bird is much too valuable as an indicator, whilst the badger's onslaughts are forestalled by a contrivance similar to the rat-rings seen on ships' hawsters.

When a badger is not forthcoming, the bird

makes for the first native, who joyfully gets together some crude kind of bee-smoker, shoulders his shovel and falls into the train of his excited guide. In wet weather the spilt honey forms pools which quickly ferment, and then the badger, drinking deeply rather than wisely, behaves in regrettably human fashion.

BABOONS' RESPECT FOR THE DEAD

An ascending review of the animal scale is as though one walked through a dark tunnel with the light showing at first as a mere pin-point far ahead, but growing more insistent with each step taken until at last the walker finds himself in full daylight. The daylight we may here take to be our modern human society—if indeed we have already reached high noon.

Had space permitted, we might have dwelt at much greater length on the crude outlines of human society as seen in the animals most nearly related to ourselves—the apes and monkeys. When some years ago all the chief zoos were trying to keep—not too successfully—large gatherings of baboons, the “humanity” of these animals was illuminating, and to the ultra-conventional sometimes rather shocking. There was the same aggregation of cliquish

family groups dominated by elders, with rebellious youth “knocking at the door.” There were the beginnings of a kind of morality, and as in some higher gatherings, the female delinquent paid more heavily than the male for any irregularity. The intimate mutterings and interchanges of the elders when a crisis faced the community were reminiscent of the town council, and even of the senate. Baboon society was not without its hints at a crude respect for the dead. Whereas a cow whose calf has suddenly died will pass on after a brief lamentation, the baboon mother cherishes her lifeless babe until its remains have become mummified. The baboon colony was far above the machine-like “civilization” of the ants.

ANIMAL RECLUSES

The converse of society is solitude, and the higher mammals can provide many an example of the recluse. Here again the human analogy needs no forcing. The rogue elephant and man-eating tiger, solitaires both, are usually forced into their lone careers through disgruntled age coupled with failing health.

The fundamentals of society can be traced throughout the whole mammalian series.



MOUNTAIN SHEEP AS SENTRY

SPENCER ARNOLD

Sheep, particularly wild sheep, have a well-established battle code. When threatened, the ewes and lambs go to the rear and the rams advance on the enemy in succeeding ranks.



UNIVERSAL PROVIDER OF THE FAR NORTH

The hardy reindeer supplies the Eskimos with transport, milk, meat and clothing. They live on tree lichens and reindeer-moss. Unlike other kinds of deer, both sexes have large antlers.

ANIMALS IN RELATION TO MAN

IT is customary to regard this as a mechanized age. Petrol is supplanting the original horse-power by a mechanical counterfeit, and synthetic substitutes for homely commodities increase daily. Yet we are scarcely less dependent upon animals for our existence than was the cave man.

Human society still draws much of its food from flocks and herds and the teeming population of the waters. Animals continue to supply the bulk of our clothing from boots to headgear. As regards adornment, some folk incorporate in their attire a veritable zoo. Beasts provide furs, and birds, plumes; shell fish furnish pearls and buttons; insects are a source of dyes, pigments and trinkets of various kinds.

Necessity and luxury combined take a staggering toll of the world's animals. Often a harmless and beautiful creature, as for example the egret, will be driven to the verge

of extinction at fashion's decree. Not infrequently Nemesis follows upon short-sighted exploitation of a creature's helplessness. Thus, in recent years, the trade in Central African monkey skins has been followed by plagues of locusts, insects which the monkeys previously kept in check. Similarly, the modern craze for snake and lizard skin commodities has seen in the home countries of these reptiles terrifying visitations of rats and mice, which have spelt ruin to the local farmers.

Animals have been drawn upon for drugs as liberally as for food and clothing. The modern pharmacopœia is almost as full of animal nostrums as was that of medieval times, though we may be glad that the preparation of such medicines has changed considerably. The physician no longer urges his patient to swallow live frogs for rheumatism, or "pill bugs" for colic. But we have derived insulin from the

calf, isinglass from various fishes, blistering agents from divers insects, and beneficial oils from a variety of animal sources.

The ferret has been enlisted in the war against influenza, and a cure for hæmophilia or bleeders' disease found in the venom of Russell's viper, one of the world's most deadly snakes. It reduces the time taken for blood to clot from thirty-five minutes to seventeen seconds. Hundreds of patients have been treated successfully



DANGEROUS BUT USEFUL

The python sometimes lays more than a hundred eggs at a time. Its skin is used for shoes.

since 1934, when the first practical test was made. Poisoning, cancer and epilepsy cases have been dealt with in a similar way.

Animals of every kind are enlisted to aid in medical research, and even the age-old quest for renewed youth has sought the means to its goal amongst animals. How wealthy senility has borrowed the "gland of hope and glory" from apes and monkeys is now ancient history. East of Suez there is still a thriving trade in rhinoceros horn, pangolin scales and monkey gall stones for a like purpose.

Where amusement is demanded, no animal is safe. The bull fight is by no means confined to Spain. In Great Britain bull-baiting has only just passed out of living memory, fox hunting, deerstalking and the annual slaughter of game are still as popular as ever, while the rise of greyhound racing proves how universal is the instinct for the chase.

Fish fights are to the Siamese what horse racing is to Englishmen and are controlled by equally elaborate legislation. In British India

the demand for hunting-leopards (cheetahs) is so great that dealers are now scouring Africa to meet the market, the home supplies having grown inadequate.

Mechanised transport, despite its amazing development, is of so recent introduction that two-thirds of the world still largely depend on animals. They are the most cheaply fuelled form of transport in existence. Even in England draught dogs were abolished by law less than a hundred years ago, and not entirely on humanitarian grounds. They impeded horse traffic, particularly in London. Dogs continue to haul wheeled vehicles throughout the Continent.

CHINA'S FISHING CORMORANTS

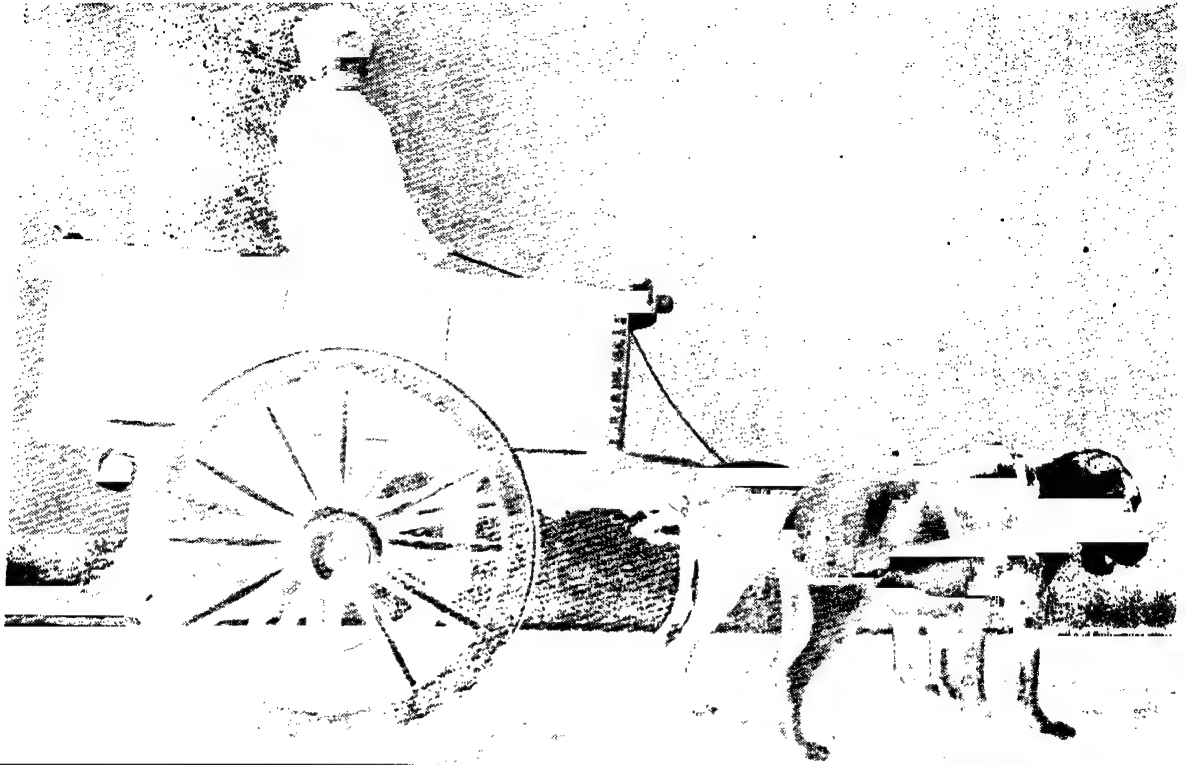
Animals are used the world over in all kinds of curious side-lines of human activity. China has its fishing cats and cormorants; in Malaya monkeys are trained to harvest coconuts. The Florida turtle traders use that curious fish the remora to capture the slow-witted sea tortoise, as did their forbears eight hundred years ago. Fortunes are yet being piled up from the bee's honey, the cochineal bug's brilliant dye, and the guano of bats and sea birds.

Only today are we beginning to realize fully the vast possibilities of animals for human prosperity or the reverse. None is now regarded as insignificant, from the worm turning the soil, to the thrush which checks the worm's too lavish increase. As a result, we are seeking to make good the harm done by past centuries of ignorance and improvidence.

MAN THE DESTROYER

Animals all but exterminated by former exploitation are being reinstated on the game reservation, the bird sanctuary and the fur farm. The laws of animal life are being keenly studied in numerous up-to-date zoos. For the study of animal parasites, which promises to become an all-important branch of economic zoology, experimental farms and research laboratories are springing up all over the world. The systematic study and safeguarding of the world's fisheries has been placed on a sound footing during the last forty years.

Thus briefly we see how much we owe to the world's animals, the vast army of its unenfranchised citizens. The increase or decrease, improvement or the reverse of this army are largely under our control, and may well command the attention of all, since all are involved. Animals enter into almost every conceivable phase of man's activities, have inspired some



DOG-CART IN MORE THAN NAME

CHARLES ALFRED HAMILTON

Two-thirds of the world still largely depend on animals for transport. In England draught dogs were abolished by law less than a century ago; they continue to haul carts on the Continent.

of his most wonderful inventions, and have coloured his art and literature, folk lore and religious beliefs since first he attained to human estate.

Judged by cave drawings and bone carvings, which are the oldest human documents, man the world over was at first a destroyer and nothing more. He slew with crude stone spears and knives, slings, bows and pitfalls. Primarily man killed for food and raiment; later he began to slaughter for pleasure, a practice he still continues.

ANIMALS AS RELIGIOUS EMBLEMS

In his first primitive contacts with the lower animals, man learnt to dread some and admire others. These presently entered into his conceptions of religion and were deified. Animals figure as religious emblems in every nation to this day. Not that such deification always saved the animals from destruction.

Quite early in human history, the chase brought about automatically the semi-domestication, and later the intensified domestication of first (in all probability) the dog, then the

cat and the horse. Later sheep, cattle, pigs and various birds joined the ranks of man's enforced servants, but apart from these more or less privileged creatures, the animal world had for countless centuries no reason to hold man in anything but dread.

TIDE OF DESTRUCTION

In his nomadic days man had but two major recreations, war and the hunting of wild animals. Both these recreations were adopted with avidity by the earliest civilized communities. Incredible numbers of animals were requisitioned to provide the blood baths in the circuses of ancient Rome, and though both the civilizations of ancient Rome and Egypt added fish and shell fish to their list of cultivated animals, man continued to destroy far more than he preserved. The earliest known zoos seem to have effected little as regards the encouragement of conservation, though the one founded by an early emperor of China about 1000 B.C. may have been an exception. At least it was given the encouraging title of the Intelligence Park.

Zoo or menagerie keeping of a kind became in time a cult with almost every monarch or his sufficiently wealthy henchmen. But the domesticated or specially protected "game" animals always excepted, the tide of destruction rolled on unchecked, and apparently



CHARLES ALFRED HAMILTON

BEASTS OF BURDEN

Descendants of wild asses, there is reason to believe that donkeys were domesticated before the horse.

uncheckable. So it continued the world over, until just over a century ago.

One might with ease compile a discouragingly lengthy list of creatures that have been blotted out of existence within the last hundred and fifty years. Amongst mammals may be cited Stella's sea cow, a creature three times as big as a porpoise. It went the road the whales are going; it was killed for its oil. Some mammals have fallen to collectors' mania. The last quagga died at the London Zoo in 1864.

At least a score of species of birds have been so ardently collected, or used as food, that they have disappeared from the face of the earth. The dodo and the solitaire are classic examples. The moa of New Zealand, an ostrich-like bird

standing ten feet or more high, together with the great auk of Iceland, were believed to be alive as late as 1860, but though rewards were offered for living specimens no rewards were ever claimed. It is known that the mariners early in the last century used to drive the great auks like geese down gang planks into the holds of their ships for victualling during a long voyage. The giant tortoises of the Seychelles and Galapagos were used in the same way.

TOLL OF COMMERCE

Commodus, one of the more degraded of the Roman emperors, once killed one hundred lions in the Roman coliseum at a single performance. This was with the naked sword. Gunpowder soon after its invention made the orgies of Rome seem insignificant. Today even the largest bags by unintelligent trophy hunters are dwarfed by commercial slaughter with the most up-to-date weapons. Here are a few figures culled from recent official reports issued during the last few decades.

In 1906 Norwegian whaling companies killed nearly two thousand whales, but with improved methods quadrupled this by 1923. In ten years only, Japan, quite a novice, accounted for close upon twenty thousand leviathans, and seventeen years' whaling in the South Shetlands removed over one hundred and twenty-two thousand animals.

Whales have at least this advantage over the hunter, however efficient his equipment—they live in the sea, a vast and often unassailable sanctuary. The terrestrial fur bearers enjoy no such protection and have suffered accordingly. During the three years 1919–21 over ninety-one million skins, representing eighteen species of the more common fur-bearing animals, came into the market. Of the more valuable there were only eight and a half millions. Close upon two million kangaroos figure in the list, fourteen million squirrels, the same number of muskrats, and over two hundred thousand koalas.

SAVING THE KOALA

No reasonable objections, perhaps, can be raised to wolf, muskrat, squirrel or the various farmed creatures, such as nutria and foxes, figuring in the list; but the same cannot be said concerning the koala, the little arboreal marsupial that inspired the popular teddy bear. This animal is entirely harmless and subsists solely on the leaves of one or two only of Australia's two hundred kinds of gum tree.

In 1927 the then Queensland government

THE ANIMAL KINGDOM



FORMER INHABITANT OF ENGLAND

WIDE WORLD

The wild boar was stamped out of Great Britain because it was harmful to agriculture and to the peaceable enjoyment of the countryside. It is still preserved in parts of Europe.

raised the ban placed upon the slaughter of the native "bear" or koala. In a month over half a million adults were killed, and two hundred thousand infants used for dog meat.

IMMUNITY AT A PRICE

At the end of 1937 there were only about five hundred thousand native bears left in Queensland, but by that time a bill had been passed prohibiting under severe penalties any further slaughter of these animals, while some hundreds had been captured and placed in reservations.

Timely propaganda succeeded in rousing public indignation against the plume trade, but the ultimate salvation of the fur bearers must be looked for in another direction. One by one many of the once most profitable species are virtually disappearing, so that the slaughter of the last survivors is not a business proposition—and so they gain immunity, at a price.

The figures quoted represent but a drop in the ocean of blood spilt for pleasure or profit within comparatively recent years. Much senseless butchery still continues, but something like an awakening to the possibilities of animal life wisely used and controlled is now taking

place in all the more advanced nations. We will glance at some of the results achieved.

Many of man's greatest disasters, like his triumphs, have resulted from a too ready grasp at the needs of the moment, without due forethought to the possible consequences. Side by side with the indiscriminate slaughter of animals he has effected introductions of all kinds. We owe some of our most useful animals to such experiments, and sometimes we have lived to deplore them.

MENACE OF THE RABBIT

All too easily can man upset what is loosely called the balance of Nature. The balance is never the same for long: it sways back and forth as first one and then another plant or animal gains temporary mastery. The balance may be likened to that of an unsteady trapeze artiste—ever on the brink of a crash, but righting himself at the last moment, as by a miracle.

As the result of persistent endeavour, the wild boar was stamped out of Great Britain because it was harmful to agriculture and to the peaceable enjoyment of the countryside. Charles I, however, endeavoured to re-establish

this ferocious and destructive animal in the New Forest, but we are told "the people rose against them." The people are rising against some other importations with less success.

We may regard the sparrow, rat, cockroach and other undesirables as accidental introductions for which no one is specially to blame. The rabbit ranks amongst our unfortunate experiments. Originally, the rodent probably

valuable cattle may perhaps break their legs in its concealed holes. The rabbit supplies good and cheap food, its skin gelatine, and its hair such "luxury furs" as leopard gazelle, electric coney and other remarkable pelts unknown to nature. Rabbit fur also provides felt, and the animal's manure may be of some value. Yet the time has come when many are beginning to wonder if the animal pays for its keep. Looked at from its many facets, the rabbit problem is very real and daily growing more insistent. It is estimated that damage to the value of £50,000,000 a year is done by the wild rabbits of Great Britain.

REMEDIES IN NAME ONLY

Even if a war of extermination were practicable, it might find as many opponents as votaries. The rabbit is one of the mainstays of the fox's larder. Apart from the obvious effects which a rabbit famine would have on the already harassed poultry farmer, fox hunting—which also has its critics—circulates millions of pounds annually in England and provides more or less regular employment for a small army of people of every grade.

In Australia the rabbit, introduced much later than in England, of course, has long been such a scourge that every year scores of thousands of carcasses are burned as the only means of disposal.

The balance of Nature can never stay for long the same, once man, by elimination or addition to the existing state of things, sets the wheels of change in motion. Some remedies for the rabbit plague, for instance, have proved almost worse than the plague itself. On one sparsely inhabited island the human inhabitants introduced cats. The cats soon wiped out the rabbits, and their introducers were faced with eating cat in place of the rabbit of which they had already tired.

SPARROWS GIVE PLACE TO STARLINGS

Within living memory we have seen a radical change in the bird life of great towns, both in America and Great Britain. At home the motor has wiped out the trade in marsh birds from Norfolk in a curious manner. When London relied solely on horse buses, immense quantities of marsh grass were bought from East Anglia to feed the bus horses. Marsh grass areas regularly cut provide just the right nesting grounds for snipe and plover. Now the grass grows rank and high, the birds have migrated, and the trade in them, so far as



GROWS NUTRIA FUR

WIDE WORLD

The coypu lives in South America and the West Indies. It provides the world with nutria fur.

came to us after the Norman Conquest, and was kept within enclosure by the feudal landowners. But rabbits burrow, and there is no knowing where they will turn up next. The rabbits having broken bounds, reduced much pine forest by eating the seedlings, and so made way for heather in place of timber.

For centuries no other harm was done since the abundant stoats and foxes kept the rabbit in check. But for the last century or more the rabbit has been a steadily growing menace to agriculture, thanks to another importation, the pheasant. Where the pheasant is, none of the rabbit's natural foes—bar the fox—is allowed to exist. As a direct result of what we may term rabbit pressure, grass has now supplanted trees, heath and rushes on many acres: it can grow where the other plants have been eaten to vanishing point. With fewer stoats, hawks and owls to worry it, the rabbit turns from mere grass to young corn. Forty rabbits can eat in a day enough to maintain a cow or an ox.

The rabbit not only eats abundantly but spoils banks and riddles open ground, where



WIDE WORLD

SOME OF THE SPARROW RESIDENTS OF VIENNA

What appear to be leaves are sparrows. In Australia the bird, imported by ones and twos long ago from the Motherland, is a serious pest. In London the starling has partly supplanted it.

Norfolk is concerned, has come to an end.

The sparrow is gradually disappearing from London, and the starling is taking its place. This is another result of the motor age, which has cut off the London sparrow's main food supply—the droppings from horses' nose-bags. Something similar has occurred in America, where the starling is an introduction. Presently the birds may have to be kept within bounds, as have London's civic pigeons.

SEARCHING A TRAIN FOR A BIRD

Recently, a transcontinental train in Australia was subjected to a rigorous search—for one sparrow. In Eastern and Central Australia the sparrow, imported by ones and twos long ago from England, is a serious pest. A fine of £100 is imposed on anyone harbouring a sparrow. When, therefore, it became known that a stowaway sparrow had landed from a freighter at Fremantle and had boarded a train, committees were formed to track it down and prevent it reaching the west, an area hitherto kept

sparrow-free by the barrier of the Great Central Desert.

This dread of the sparrow is very justified, for the bird has the hall-mark of a good colonist—adaptability. It is almost as great a world traveller as the common snail of English gardens, which can be met with in Morocco, feeding with customary gusto on the prickly pear cactus when nothing better offers.

We are only now realizing that it is not enough merely to deposit a foreign animal in our own country under conditions which promise to suit it; they may suit it too well.

SUPPRESSING THE MUSKRAT

When, a few years ago, it was realized that the muskrat would become a menace in Great Britain, the most drastic steps were taken for its suppression. Now the various fur farms—fox, nutria, mink, etc.—established to make good the havoc wrought by promiscuous massacre, are under the strictest supervision.

In the British Isles the grey squirrel, like the

rabbit, has also gone too far. The climate is not cold enough to make its fur of marketable value, and racial conservatism precludes its general use as food, though it is superior to rabbit in this regard. The animal is merely a nuisance and an expensive one.

Up to the year 1800, Great Britain was, as regards the general attitude towards animals, much where it was in medieval times, when

the Prevention of Cruelty to Animals. In 1820 the Zoological Society of London was founded.

The story of this body has been told in detail in other books, and is only mentioned here as a conspicuous milestone on the road to better things. One of the Zoo's most energetic champions was founder of the famous Smithfield Club, England's oldest fat-stock show society. The Zoo had great hopes of introducing new food animals, and devoted its earlier years to their establishment without success save in one direction, poultry. It inaugurated the first poultry show, and helped to establish a huge network of poultry societies and agricultural research stations. It inspired the first dog shows, and incidentally the first homes for lost and starving dogs.

ZOOS INSPIRED BY LONDON

Apparently, the society, despite early predictions to the contrary, was founded at a fortunate time. The world was ripe for it. The amused curiosity it first aroused soon gave rise to enthusiasm. Within twenty years of its inception it was enjoying to full measure the sincerest form of flattery. One by one every other country followed in its wake, not only setting up zoos, but communicating with London, and establishing many other institutions similar to those the Zoo had inspired.

The London Zoo came too late to save some of the native animals, the great bustard for example, but other countries by vigorous action rescued from extinction valuable and interesting items of their fauna.

REINSTATING THE BISON

An outstanding instance is that of the American bison. Less than a century ago the animal was counted by hundreds of thousands. Greed decimated its ranks. There are even records of how American Indians and cowboys, in drunken frolics, stampeded whole herds of bison over precipices "for fun." Today the American Bison Society and scores of affiliated bodies have reinstated the animal and made it one of the country's most valuable natural resources.

Naturally enough man's attention as regards animals was primarily concentrated upon terrestrial species. He realized the necessity for their protection, but the flocks and herds of the sea he left largely to look after themselves, taking his toll of them as occasion served, confident in the soundness of the ancient



WIDE WORLD

VICTIM OF FASHION

The crested crane, once destroyed in great numbers because its feathers were demanded by fashion.

the only protective measures consisted in savage punishments meted out to those who stole the king's deer. Animals were tools and playthings, of use in crude agriculture, transport, sport and quackery.

There were only two zoos, as opposed to beast shows, in the world. One, of long standing, was at Vienna in Austria, the other and slightly younger institution was the scientific mecca of the period. Every biologist and scientific investigator sooner or later paid a visit to the Garden of Plants in Paris. Apart from the Royal Society for the elect few, England in 1800 was in a state of barbarism, and mightily amused at the efforts of a few fanatics struggling to establish a Society for

maxim, "There's lots of good fish in the sea."

He believed much the same of freshwater fishes, bar the salmon, which he guarded with the same savagery as he did the royal venison. Even the far-sighted Thomas Henry Huxley shared the general attitude, and encouraged it by declaring, "Fish where you like, when you like, and how you like." Such was his confidence in the apparently inexhaustible fecundity of the seas.

FIGHTS CAUSED BY HERRINGS

Inconsistently enough, despite this childish faith in the sea's unbounded riches, extraordinary greed and jealousy were shown in the gathering of them. Many fierce naval engagements between European nations had their beginnings in a selfish desire on the part of each belligerent to monopolize the herring fishery.

It was in 1853 that the London Zoo opened its aquavivarium, the first exhibit of its kind, as opposed to the monkish stews and the Roman fish and oyster ponds. The aquavivarium, for want of those engineering devices indispensable to successful aquarium keeping, was in the end a dismal failure. But in its short lifetime it not only inspired the equally short-lived aquarium craze of Victorian times, but the now highly organized safeguarding of the world's maritime resources. The Zoo's 1853 effort had in its turn been largely instigated by the books and other propaganda of P. M. Gosse, who little realized the vast machinery his ready pen and brush were to set in motion.

Less than twenty years after the aquavivarium opened, there was founded in Naples by Anton Dohrn, a German biologist, the first marine research station. This was established partly from his own private resources, aided by contributions from enthusiastic sympathizers, and grants from the Italian and German Governments. In England the only efforts to safeguard and control fisheries of any kind were in the hands of the indefatigable Frank Buckland, the father of fisheries so far as the United Kingdom is concerned.

WORK OF MARINE LABORATORIES

It was not until 1884 that Great Britain awakened to the parlous state of her ocean resources. In that year the Marine Biological Association of the United Kingdom was established, and an aquarium and research laboratory built on part of the old citadel site at the eastern end of Plymouth Hoe. Today

there are about two hundred such stations scattered over the world, the nations with extensive coastlines, England, America and Japan, naturally having the greatest number of stations.

A marine laboratory deals with every conceivable phase of ocean life, from tracing the histories of the most obscure plants and animals to the study of wind, water and the formation



ALLY OF THE CHINESE

WIDE WORLD

The cormorant, which the Chinese have trained to catch fish without swallowing them.

of the sea bed. As in agriculture, the farmer of the seas can afford to neglect nothing; all is significant.

When T. H. Huxley voiced his optimistic dictum, he spoke at a time when the leisurely sailing trawler and the seine net and long line could supply all the fishes the nation needed. But soon steam was harnessed to feed an ever-growing populace, and when the first steam trawler left harbour the security of the harvest of the sea was at an end. For in fishing one is reaping where one has not sown, and that can no more continue indefinitely at sea than on shore. The steam trawler, now vital to supplies, destroys at the lowest estimate a

hundred times more than it brings to market.

Not only are countless young fishes killed and shovelled overboard, but in addition thousands of tons of the invertebrate life on which so many feed, and the roes of fishes which might otherwise ensure the harvests of many years to come are destroyed. Prejudice is so great that many wholesome kinds of fishes are automatically scrapped, and owing to the inevitable interdependence of all life, ashore or afloat, their loss is soon felt by the few fishes which meet with our unadventurous approval.

Apart from all this wastage the steam trawlers, now countable in thousands, carry devices for negotiating rocky ground that was closed to the old-style trawls, and by working winter and summer, and in almost any weather, scatter the fish when on their breeding grounds.

How greatly the game preserves in the seas may benefit from judicious resting periods was proved just after the World War, when for a short time fishes of all kinds were extraordinarily abundant, as a result of four years' comparative immunity from molestation. Regulating the mesh of nets, closing certain areas for recuperative periods and patrolling the seas to enforce

observance of the fishery laws are useful measures still in their infancy. The difficulties are great, for the storm-torn and often fog-bound seas cannot be controlled as can a pheasant covert, or even great inland reservations like the Kruger, Yellowstone, Akeley and other animal parks now established in various parts of the world.

ROBBING THE OYSTER

River and coastal waters, though obviously much more patrollable than the open sea, have fared even worse. Just over a century ago the Thames boasted scores of fishing villages between the Nore and Teddington. Pollution of the waters has made them all no more than memories. Pollution has also rendered necessary the elaborate and costly purification tanks associated with England's oyster fisheries, established for the most part near or in estuaries.

Coastal waters may also be ruined, no less than the land, by hastily considered or accidental introductions. A case in point is the slipper limpet, the curious brazil-nut-sized shells of which may be gathered by the bushel on almost any beach in Great Britain. This sea snail was unknown in English waters prior to 1880, when it is believed to have been landed with a cargo of oysters from America.

The slipper limpet eats the same food as the oyster, and by multiplying at an amazing rate not only robs the valuable mollusc of its rightful nourishment but by sheer weight of numbers smothers it. Further, the creature appears to have few if any natural enemies in the waters of its adoption. Twenty tons a day are often dredged in the Essex estuarine alone.

SHELL-FISH SCOURGE

The sale of the shell for grit and other purposes offers small compensation for the expense of dredging, or the loss of oysters. The snail itself is both wholesome and tasty, but ranks with other good fare amongst the national taboos. Regarding this, Dr. J. H. Orton, the leading authority on oyster culture, writes: "One has the impression that if *Crepidula* (the slipper limpet) occurred in France . . . means would soon be found to convert it into a cheap source of food." One has only to remember that prior to 1903, when the government set about popularizing dogfish, now the mainstay of fried fish shops, this excellent dish was almost universally regarded as uneatable.

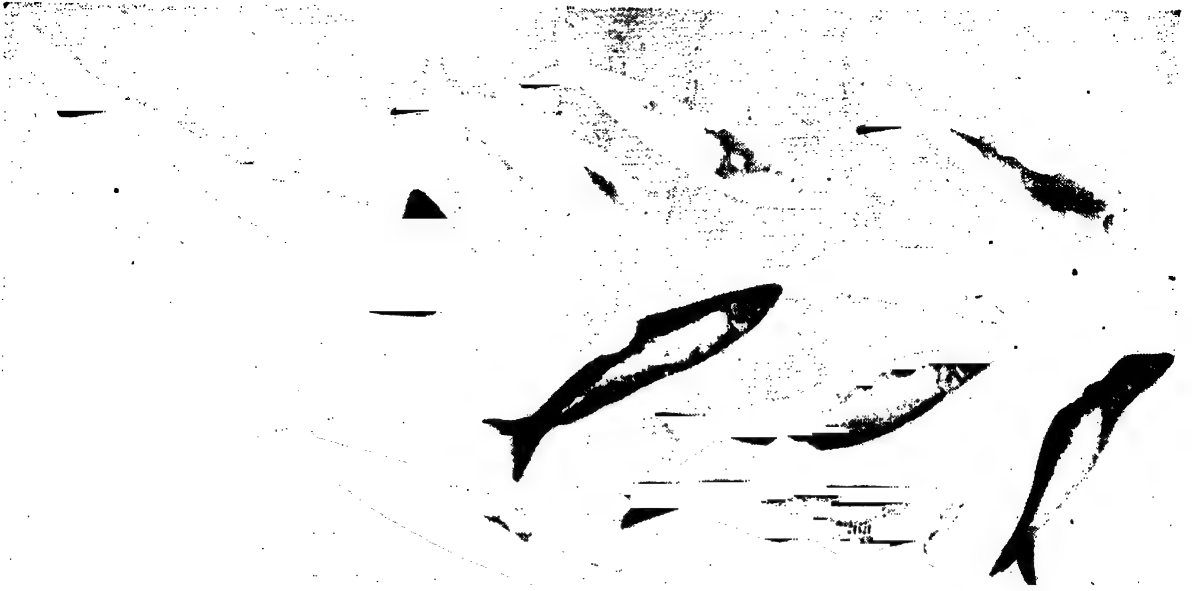
Another shell fish scourge, though of less



WIDE WORLD

SALMON LEAPING A FALL

The salmon spawns in fresh water, perhaps its original home. The Thames was a salmon river until pollution drove the fish away.



WIDE WORLD

DOGFISH AND THEIR VICTIMS

Previous to 1903 dogfish were almost universally regarded as unfit for human food. They play havoc with young herrings, and sometimes content themselves by biting out small pieces as pictured above. Left: dogfish.

import, is the zebra mussel, brought to Great Britain with timber from the Baltic some fifty years ago. The shell, which is about the size of an edible mussel, multiplies so fast as often to choke water mains. A three-foot conduit at Hampton had its bore reduced to nine inches as the result of this mollusc's fecundity.

NURSERIES FOR COD

Dr. Julian Huxley, in speaking of the balance of Nature, has referred to "the subtlety of the web's weaving, whereby a twitch on one life thread alters the whole fabric." This applies in like measure to the reactions of one plant or animal upon another, and man's control of them. Intensified methods of fishing have brought about intensified measures for propagating fish artificially. In Canada the salmon wheel catches the fish by thousands as they ascend the rivers, and hurls them straight into the cannery.

Parallel with this mass destruction has grown up a system of fish farming whereby ova and milt are taken from the living fish, intermingled, and the fertilized eggs eventually hatched in a special nursery. In America such sea animals as cod and lobster are now similarly farmed on the grand scale.

Study of the inhabitants of the seas no doubt increased the general interest in birds, their migratory movements coming under the observation of seafarers even more than landmen.

The value of birds as guides to fishing grounds, and their still greater importance to agriculture led, in 1889, to the foundation of the Royal Society for the Protection of Birds. Hitherto they were largely anybody's prey, and beneficial species suffered equally with the few pests, their alleged depredations being based largely on the observations of not too observant land workers and gamekeepers.

A year after the Society's foundation Lord William Percy made the first attempt at ringing birds for the purpose of checking their migrations. As a sportsman he confined his efforts to woodcock, but nine years later C. C. Mortensen, a Danish schoolmaster, began attaching numbered discs to the legs of such birds as he could catch. It is interesting to note how this device developed parallel with the idea of marking fish with metal or celluloid discs for a like purpose.

RECORD LONG DISTANCE FLIGHT

The practice of ringing birds was augmented by Messrs. H. F. Witherby and Sandsborough Thomas of Aberdeen University, with such fascinating and illuminating results that by 1909 the practice was common on both sides of the Atlantic.

Close upon a million birds have been thus marked during the last two and a half decades. From the records obtained it transpires that the Arctic tern holds the birds' record for long

distance flight, leaving Labrador in July, and next appearing in South Africa, eight thousand miles distant. For its size the humming bird, though travelling only over land, comes next, whilst the swallow and the stork are almost equal in their annual journeyings.

BREEDING-SANCTUARIES

Other relatively recent activities on behalf of birds are the establishment of breeding sanctuaries, the immensely popular nesting box and food-table movement, the discouragement by broadcasting of pumping waste oil from ships, which kills diving birds, and the erection of resting racks on lighthouses. These devices, supplied by voluntary subscription, save tens of thousands of birds beneficial to agriculture during their hazardous migratory flights, which so often synchronize with the equinoctial gales.

Bird protection and study is so well organized in Great Britain today that by means of

registered watchers all over the country, it has been found possible to take a census of such comparatively stationary birds as the barn owl. A similarly organized examination of the contents of the crops of various birds has resulted in many kinds once shot on sight being established as amongst the land workers' best friends and accorded the protection of the law.

IMPORTANCE OF INSECTS

In some respects the study of insects from an economic point of view is the most important of modern sciences, so far-reaching is it and so great its potentialities.

Honey, silk and cochineal dye have been appreciated, and in varying degree cultivated, by man since the dawn of history. But apart from these matters the significance of insects has only lately been realized or even suspected. Until comparatively recently all other insects were regarded as pests.



REAPING THE HARVEST OF THE SEA

When the first steam trawler left harbour the security of the harvest of the sea was at an end. Although the method of fishing which now obtains is vital to supplies, it also accounts for much wastage.



PLAGUE OF LOCUSTS IN NORTH AFRICA

WIDE WORLD

Locusts on the war path sometimes move on an immense front extending for many miles. Grass and leaves are devoured, and even boughs are broken down by the weight of the insects settling on them. During an attempt to defeat an invasion in Transjordan, two thousand four hundred and forty-seven tons of the insects were collected.

Today the study of insects is recognized as being far more vital to the interests of mankind at large than fur farming, game preservation, or even cattle breeding. Man's mainstay, the products of the soil, are at the mercy of the insect hosts as much as they are moulded by the elements. Here, as always, we learn by the expensive method of trial and error. Often a newly acquired scrap of knowledge must be discarded, or at least revised.

The gardener often uses "cures" that prove



AS USED IN GREECE

Honey has been of service to man since history began. A type of hive dating from remote times.

worse than the disease. Many of the deadly poisons with which we spray our crops to eradicate certain pests do as much harm as good, for friend and foe suffer alike. In North Africa the fighting of locusts by means of arsenic is now known to be largely responsible for the decimation of the European stork. The birds, enthusiastic scavengers, have fed on poisoned locusts and shared the fate of the insects. This has reduced their ranks quite as much as land reclamation and intensive drainage, which eliminates much insect life, besides frogs and water rats.

Comparatively few gardeners and farmers know one insect larva from another. There is some excuse for this. The British Isles alone harbour forty-odd kinds of butterflies, over two thousand kinds of moths and well over three thousand different kinds of beetles. All these produce grubs or caterpillars of a sort, and so do most of the other insect groups.

WARRING AGAINST INSECT PESTS

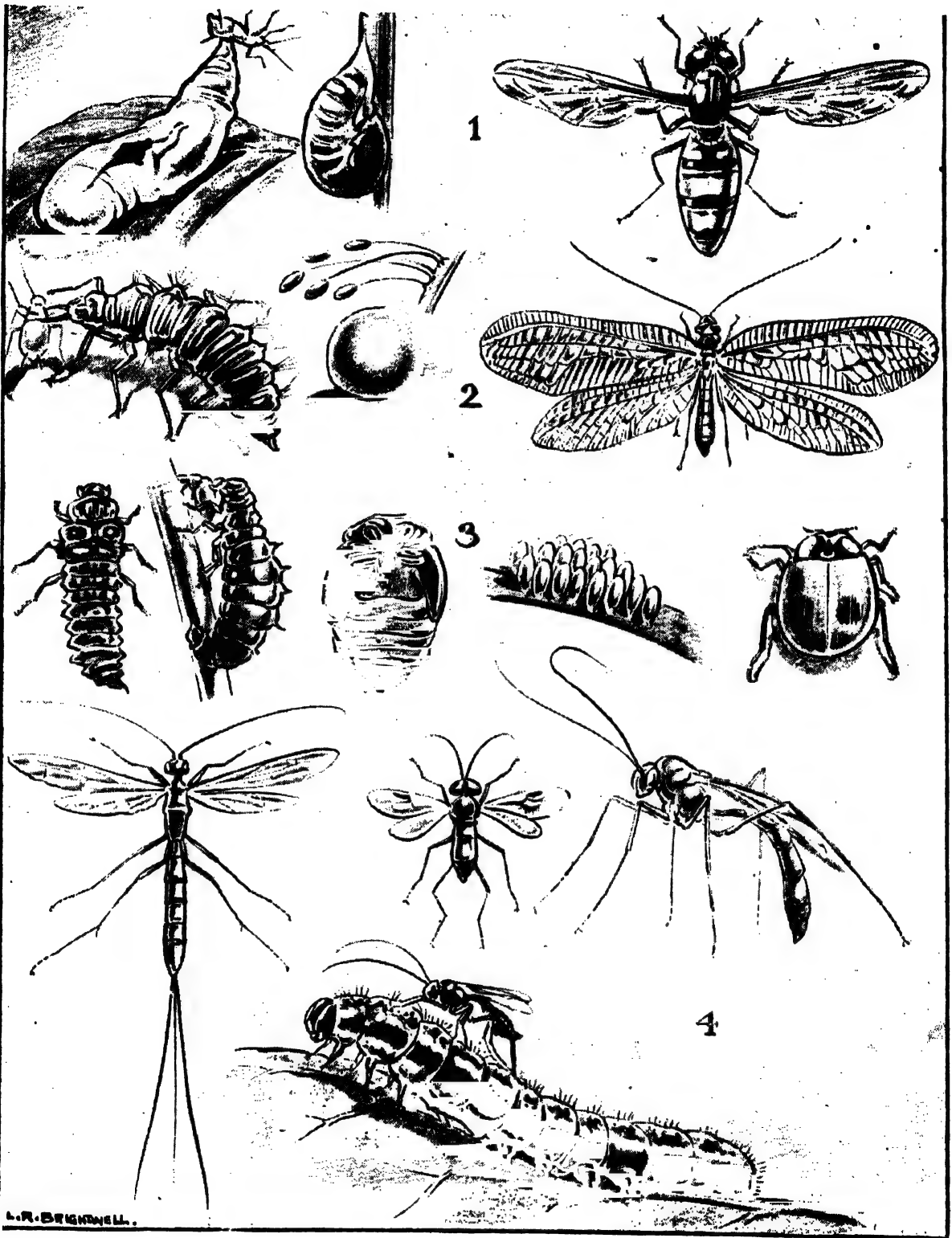
The economist cannot afford to be ignorant. This is why the Insect Department staff of the British Museum outnumbers that of all other departments by ten to one, and why all over the world there are now established State-supported colleges and laboratories for the study of insects similar to the Imperial Bureau of Entomology near London. It is now being realized that a safer and surer method of killing noxious insects than by sprays or poison gases is to pit their natural enemies against them. Much romance and high adventure is embodied in the cut-and-dried reports on some of these attempts to fight one insect with another. Not least of the difficulties involved lies in finding an insect to do the work required—and none other. We have already noted some of the dangers attending reckless introductions.

LADYBIRD FACTORIES

Let us take a typical triumph of the economic entomologist. At the beginning of this century Hawaii's sugar-cane crop was threatened by a weevil—a plant-boring beetle. After two years' search an entomologist found on the Pacific Island of Amboina a fly which preyed upon the weevil. Setting out on the four-thousand-mile voyage to Hawaii with a cargo of flies, the entomologist fell ill and all his hard-won insects died.

The fly had a short life cycle and was therefore difficult to breed in confinement. Eventually, it was realized that the only way to get the flies in bulk to Hawaii was to breed successive generations *en route*. By bringing off "crops" of flies first at Queensland, then at Fiji, they at last reached the scene of operations, and the weevil was doomed.

The earwig is a plague in some countries where it has been introduced, and in America—another introduction from England—the gipsy moth threatened vast areas with ruin until its parasites were discovered and sent to join it. The ladybird's now known voracity for greenfly has given rise to what are literally



INSECTS BENEFICIAL TO AGRICULTURE

1. Grub, cocoon and perfect hover fly. 2. Grub, cocoon, eggs and perfect lace-wing fly. 3. Grubs, chrysalis, eggs and perfect ladybird. All these are enemies of greenfly. 4. Ichneumon fly laying eggs in caterpillar.

ladybird factories. Yet the average garden owner invariably mistakes the ladybird's voracious grub for "some sort of slug," and in killing it helps one of his garden's worst enemies.

APPLE-BLOSSOM WEEVIL

Many an apple farmer has been brought to the brink of bankruptcy by the apple blossom weevil. Often the affected buds are collected and burnt, and to the burning go not only the beetle grubs but the ichneumon flies that eat them. If the blooms are put into a muslin bag, the weevils can spread no farther and the flies can be released to save next year's crop.

Other friends of the gardener that everyone should know are the hover and lacewing flies, also among the foes of the aphides, the larger ichneumons which lay their eggs in living caterpillars, the caterpillar-killing technid flies, often mistaken for house flies, and the more important carnivorous beetles like the big blue ground beetle, the devil's coach horse and the snail-destroying glow worm.

In the United States ladybirds retire as winter comes to the hills, but their prey, the aphides, stay in the valley, and when spring returns again start feeding before the beetles can fly

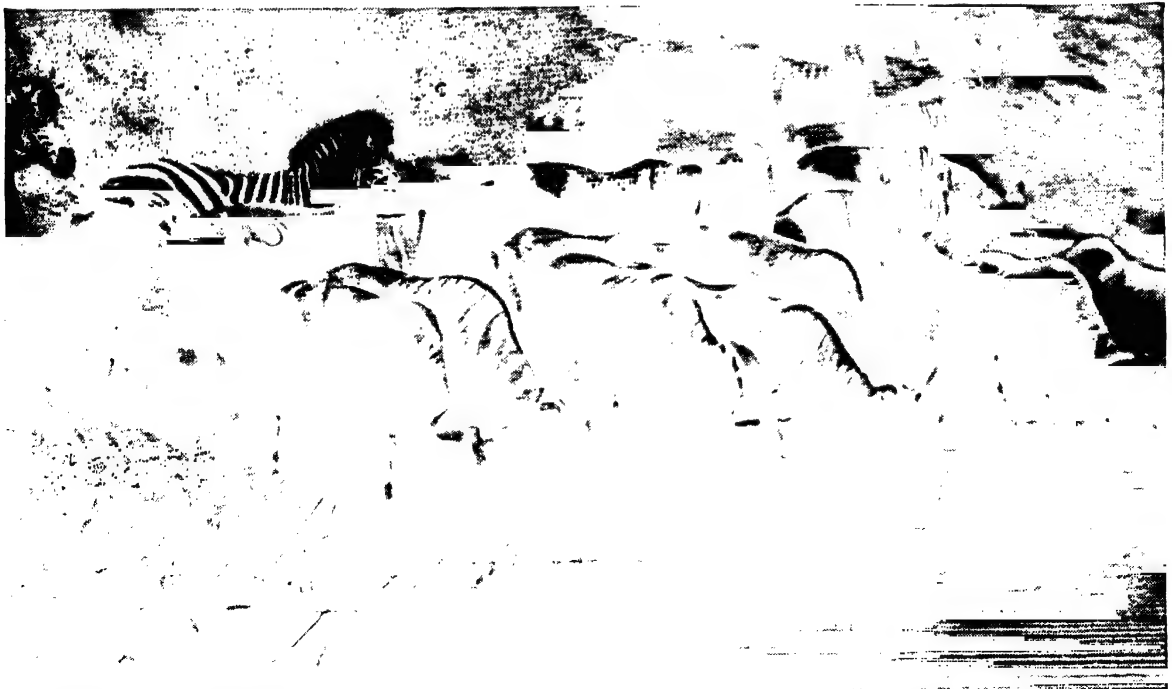
down to them. Today the ladybirds are saved a journey. They are collected by the basketful in their high winter retreats, sold at so much a pound, and given the freedom of the fields and orchards—with the farmer's blessing.

Prickly pear cactus makes good camel fodder, but when plant and beast were introduced into Australia, the cactus became so prolific that no number of camels could cope with it, for the camel is a slow breeder. The prickly growth promised to annex much of the island continent, until in 1920 an organized hunt was made for a prickly pear "pest" throughout America and the West Indies.

SPECIAL STEAMER FOR FLIES

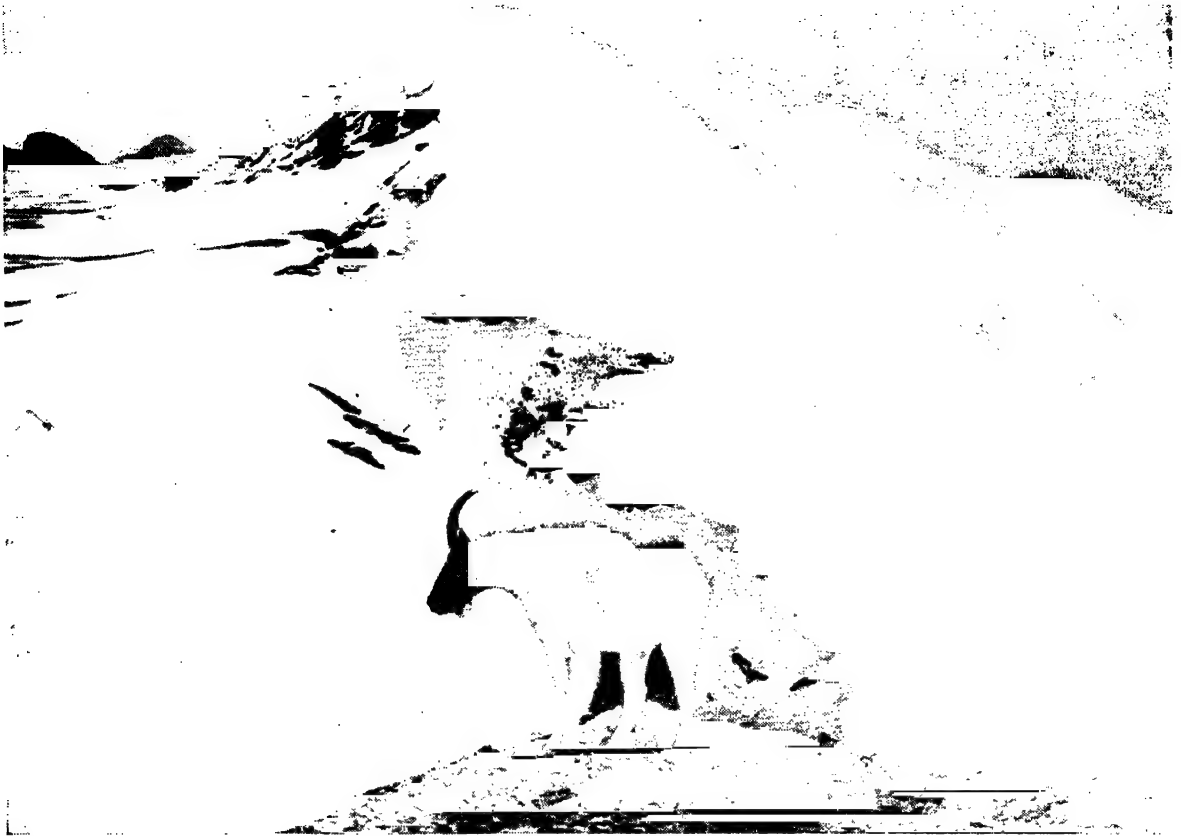
At long last there emerged from scores of trial insects the caterpillars of a certain moth, various plant bugs and cochineal insects and the "red spider"—in Great Britain a pest to fruit trees. These creatures were produced in bulk at a special breeding station founded in Texas by the Australian Government, and the animals shipped to the affected areas as required.

A parallel victory to this was the discovery in Malaya of a fly which would attack the Fiji coco-nut moth, a scourge that throughout many islands converted fruitful palms into the



MAN TO THE RESCUE IN SOUTH AFRICA

Creatures of the wild drinking together in Kruger National Park, the great South African reservation where many animals which were dying out for various reasons are being preserved in their native haunts.



PROTECTING WILD LIFE IN THE UNITED STATES

A goat in Glacier National Park, Montana, which covers no fewer than one thousand four hundred and fifty square miles and is one of several reservations in the United States. Here American Indians live in tepees and wild animals rove about at large.

likeness of hop poles. After several years' search, the first consignment of three hundred flies was obtained and sent in 1925 from Malaya to Fiji in a specially chartered steamer. Their teeming descendants assure the valuable coco-nut's prosperity to this day.

As already stated, in introducing a parasite or anti-pest, the utmost precaution must be taken by experiment to make sure that it shall do the work required, and that only, and not in its turn become a menace. The mongrel mouse, introduced into the West Indies to cope with a rat plague, itself became a pest when, tiring of rat slaughter, it found more toothsome fare in the local chickens and wild birds.

EGRETS THAT WENT A-ROAMING

Climate also must be taken into consideration. The African egrets introduced at Whipsnade kept down cattle parasites like the bot fly, but had to be collected and cosseted indoors as soon as autumn came. In the

London Zoo the birds, given their liberty, found mere cattle-grooming a tame amusement with so many other distractions to offer. Before long some were discovered inspecting the possibilities of the Regent's Canal stickle-back supply, and a few were even traced to the Temple Gardens, in the heart of London, purloining goldfish.

INSECT HELP FOR PLANTS

Whilst many insects are pests, or pest fighters, a high percentage are indispensable to the agriculturist in the cross-fertilization or pollination of plants. Geology proves that whereas plants no doubt anticipated animal life, none of the flowering and fruitful plants existed until after the insects had become well established. Some plants are self-fertilizing, others rely on the haphazard, wasteful method of broadcasting their pollen grains upon the wind, but insects offer a surer method and in flitting from flower to flower swell our crops and feed our cattle.



TINY INSECT WHICH CAUSES MUCH DAMAGE

HAROLD BASTIN

The destructive work of the beech leaf roller weevil told in three pictures which are self explanatory. The products of the soil are at the mercy of the insect hosts as much as they are moulded by the elements.

New Zealand, now literally the world's mutton factory, could at first make little success of sheep farming. Good mutton can only be raised on clover, but even when clover was introduced, little headway was made. The plants fared no better than the animals. Then it was realized that to propagate clover bumble bees are necessary, and New Zealand's prosperity dates from the day when a cargo of English bumble bees arrived. Thus mutton and beef, wool, hair, horn and leather, fertilizers, milk, cheese and butter are to a very large extent gifts from the bumble bee.

TUNNELLING LARVÆ

It has been estimated that in some years twenty per cent of the fruit crop of the United States is destroyed by insects, yet even so, as the Department of Agriculture points out, this may rightly be regarded as a tax paid on the successful production of the remaining eighty

per cent. Not only are insects useful as fertilizers. Many tunnelling larvæ enrich the soil even more than do earth worms, by dragging down leaves and other rotting vegetable waste, and converting it into manure.

ANTI-GNAT FISH

Side by side with the march of agriculture and the opening up of new lands for tillage, has gone the study of insects as enemies to the colonizer's health—their potency as carriers of disease. In Great Britain flies are relatively merely a nuisance, and might be easily decreased in numbers by increased cleanliness. The cockroach, flea and louse are three more reminders that we are still some way from a hygienic Utopia, and the gnat and mosquito might be readily controlled by proper supervision of ponds and ditches and the encouragement of such easily bred fish as the stickleback and the golden orfe.



FUR FOR THE FAIR AND THE FORTUNATE

Animals continue to supply the bulk of our clothing from boots to headgear. The silver black fox is typical of Canada's fur industry. The pioneer business men of the future Dominion were fur-traders. The price of a pair of silver foxes for breeding purposes has reached as much as £2,800.

Italy is one of the few European countries to encourage scientifically anti-gnat fish. But within the tropic belt insects still vie with man's worst engines of destruction in the toll they take of life. Large tracts of land still defy the white man's best attempts at annexation; the mosquito and the tsetse fly hold them secure.

Forty per cent of India's death rate is still due to the malarial mosquito, once a scourge of ancient Rome and Greece. It was a dread broadcaster of ague in Great Britain until less than eighty years ago. The danger of mosquito bite lies not in the incision, or even blood letting, but the conveyance of the parasite of which the insect is an intermediary host. Fleas, working through the rat, are now known to have carried the plague or black death which so many times ravaged London.

MOSQUITOES AND YELLOW FEVER

Mosquitoes carry "yellow jack," the fever that used to kill one in five of the Jamaica garrison annually, and spreading via the slave trade to Africa, wreaked a fearful revenge on slave traders and slaves alike. It was only recently traced to the mosquito as the result of an expedition in which the investigators deliberately exposed themselves to the scourge in a manner that ranks amongst the most heroic epics of medical research. Here, as

with malaria, the remedy lay in destroying the mosquito's breeding grounds, and so one day the awful history of "yellow jack" may be closed for ever.

PROBLEM OF THE TSETSE FLY

African relapsing fever is carried by lice, the intermediary hosts of the flagellate causing the disease. A tick carries red water fever to cattle in Northern Europe and Arabia, Japan and North America; another tick transmits the biliary fever to cattle and horses in East Africa, a third carries the typhus-like Rocky Mountain fever. The bed bug is now under suspicion of carrying not only typhus and relapsing fever but leprosy.

The tsetse fly, which causes sleeping sickness in man and nagara or tsetse fly disease in horses, dogs and domestic cattle, remains a largely unsolved problem. Its many natural enemies—insects, birds and reptiles—fail to produce any appreciable diminution of its numbers, but lately an ingenious device known as the Williamson trap has yielded some success.

The trap is a box, triangular in section, with a slit in the apex and a balloon fly trap mounted on the base. It is slung horizontally in shady places, which the flies always frequent, and is mistaken by the short-sighted insects for a cow. They attack the "belly"—in which is set the

slit—and wander about in the “cow’s” empty inside until they find a small hole giving access to the fly trap, and once inside they remain.

What havoc insects may work with stored as well as growing foods is known to all. Quite as spectacular are their onslaughts upon dead timber incorporated in furniture and architectural structures. The termite’s insatiable appetite for wood has been already noticed. In London two famous buildings, Westminster



PRODUCER OF WOOL AND WEALTH

Australia is the largest producer of wool, yet the sheep is not a native of the island continent. It was among the first animals to be domesticated.

Hall and Bow Church, were saved from the furniture beetle only in the nick of time. Huge oaken beams had been reduced to so much sponge.

On a lesser scale the wood-boring wasps obtrude themselves. When unseasoned wood is used, the pupæ within at last yield up the perfect insects, which may make a dramatic entry by appearing from an unsuspected spot in a living-room wall or even from a table leg. To gain its freedom, one of these wasps has been known to chew its way through half an inch of timber and a thickness of sheet lead.

Here we must close our summary of what has been done as regards the study of animals, and the application of the knowledge gained, during the last hundred and thirty-odd years.

Much unchecked slaughter has continued parallel with the world-wide spread of scientific and humanitarian societies, great and small. We have travelled a long way since Richard Martin saw the Act for the suppression of Bull-baiting passed in England in 1835.

CONSERVING ANIMAL RESOURCES

A notable post-war movement is the foundation of the Empire Fauna Society, which controls established wild life reservations and aids the formation of new ones throughout the British possessions. Italy is amongst the latest recruits to the bird protection movement, and the development of her freshwater fisheries has gone forward on model lines. The world’s newly awakened sense of responsibility regarding its animal resources is characterized by an international spirit. There is a growing tendency to pool knowledge and use it for the general benefit, which is one of the most encouraging features of our restless age.

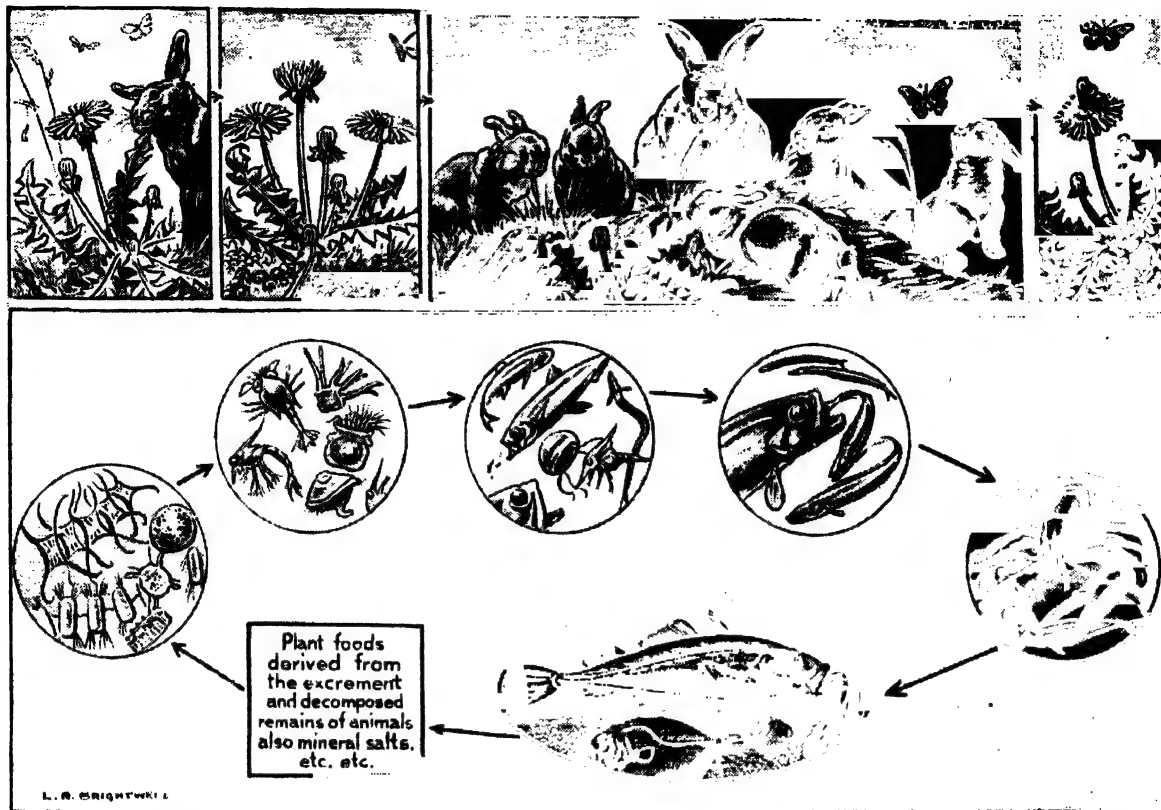
Canada and the United States possess thousands of square miles of National Parks of great beauty, where wild life is encouraged to flourish under natural conditions. Bears, moose, deer and an almost infinite variety of animals and birds enjoy a charmed existence, protected from the inquisitive and acquisitive instincts of man.

Extensive territory in the Belgian Congo is devoted to the preservation of its natural fauna and flora, including species known or reputed to be harmful. Included in it is an extensive forest where the rare mountain gorilla roams at will. The pursuit, capture, killing or molesting of any creature, and the taking or destroying of eggs, is forbidden under heavy penalties.

TRESPASSERS WILL BE PROSECUTED

Only those who are provided with a pass are admitted to the sanctuary. This rule is strictly enforced by the conservators and native police. There is also a protective zone around the park, the inhabitants of which are not permitted to use firearms or to fish.

The wonderful Kruger National Park in the Transvaal has an area larger than Wales, over eight hundred miles of road for visitors, and several rest camps. “We, the animals of the Kruger National Park,” writes the warden in their name, “appeal for your sympathy and friendship. You have been our bitter enemies for so long that it takes time to make us understand that a new and happier era has begun for us—do not betray our trust in you.”



PLANT AND ANIMAL LIFE DEPEND ON EACH OTHER

Plants feed animals, whose waste products help to feed plants. Minute floating plants, fed by the chemical products of animals, form the basic food of animals in the sea until they prey on others.

THE PLANT KINGDOM

A VAST assembly of forms is included in the plant kingdom. There are at least two hundred and fifty thousand kinds of flowering plants. Fundamentally the living matter shows the same characteristics as in animals, but plants are mainly a sedentary group, they remain anchored in position by their roots and do not seem to us to display much activity, for all their movements are slow. One notices that at night daisy flowers have closed and the clover has folded up its leaflets. The same sleep movements are shown by the sensitive plant *Mimosa pudica*, which will also respond convulsively to a touch, the leaflets folding up and falling back. This is exceptional, for the pace of most plant life is much more gentle.

Slow-motion cinematography has aided the understanding of plant activity. Pictures of a plant are taken at intervals of perhaps a minute and are projected on a screen at the usual rate

of sixteen a second. The speed of the movements is thus magnified tremendously. Roots writhing their way past the obstacles in the soil, shoots working spirally upwards and jostling their neighbours, and leaves fluttering up and down give an unforgettable picture of purposeful movement, making the verb "to vegetate" seem a libel on the plant kingdom.

The aerial parts of typical plants, particularly the leaves, are coloured green by the presence of a pigment called chlorophyll, which is really an intimate mixture of two green and two yellow substances. It is of the greatest importance in plant nutrition, and its presence is one of the main distinguishing features between plants and animals. The latter nourish themselves by taking in solid matter derived from plants or other animals; plants, with the aid of chlorophyll, make their food inside their bodies from simple materials and may literally be said to live in part on air.

The plants which occur in greatest quantity and form a carpet over most of the land surface are those which reproduce themselves by means of flowers and seeds. In the evolutionary scale they are the latest and most successful development. Besides them there are simpler types, the ferns, mosses and liverworts, the algæ (pondweeds and seaweeds) and the fungi (mushrooms and their relatives). Something of the life and reproduction of these groups will be briefly mentioned after a closer study of the life of typical flowering plants.

From a pennyworth of cabbage seed we can raise a number of plants which represent at maturity an enormous increase on the original substance—a seed whose weight we hardly notice producing a plant of some pounds. Whence has the cabbage, sitting quietly in its place, obtained the material for this growth? To answer the question we must first inquire of what the tissues are composed.

FOOD OF GASES AND LIQUIDS

Every housewife knows that a large proportion of it is water, perhaps four-fifths, for the bulk of the leaves diminishes rapidly as water is extracted in the cooking process. If by heating more strongly all the water is driven off ("the saucepan boils dry"), the leaves char and turn black, just as a burnt match does; the substance produced is charcoal, one of the forms of carbon. Still greater heating would reduce the leaves to a little heap of ashes, in which the chemist could detect various mineral elements, such as potash, calcium and iron. Besides these he would have found that part of

the leaves vanished into the air in the form of gases, among them nitrogen.

If we cared so to treat a joint of beef we should get much the same results, for the chemical compositions of living plant and animal tissues are fundamentally very similar. Now the bullock obtained its material for growth by eating grass and other fodder, but plants have no mouths and stomachs and cannot take in solid matter. The only possibility then is that they make use of gases and liquids. Like us they are surrounded by the air, a mixture of the gases nitrogen, oxygen and carbon dioxide, while we know that there is water in the soil and that there are likely to be substances dissolved in it.

WORK OF THE ROOT-HAIRS

If a hyacinth is grown in a glass the level of the water continually falls below that which would be lost by simple evaporation. It is obvious that the roots are absorbing it. So, too, they take it from the soil, although we rarely can see the water there. Normally it forms a thin film round the tiny soil particles and is only visible to us in poorly drained, waterlogged soil.

Only a part of the root can absorb water. Cress seeds, grown on damp flannel and kept covered, will show a fine fringe of delicate hairs surrounding the rootlets from close behind the tip to an inch or so farther up. These so-called root-hairs consist of a single cell with a very delicate wall, which in nature comes into the closest possible contact with the soil particles and their water films.

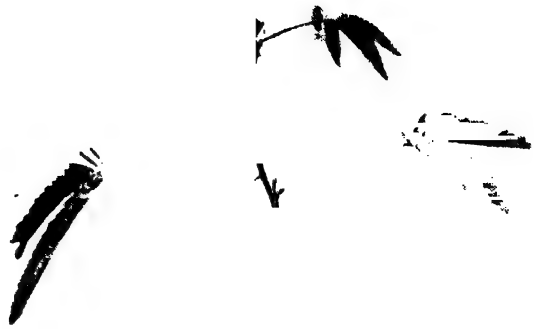
To understand the way in which the root



HAROLD BASTIN

ACACIA AWAKE AND ASLEEP

Left: an acacia with its leaves responding to the sunlight of the early morning. Right: the same plant "going to sleep" at sunset on the same day.



HAROLD BASTIN

WELL NAMED THE SENSITIVE PLANT

*Nearly all the movements of plants are slow, but the sensitive plant will respond convulsively to a touch.
Left: leaves expanded. Right: immediately after having been touched.*

hairs allow water to pass in through their walls we may think of a limp cucumber which has been put in a basin of water. It will not be long before it has been made plump and stiff by the entry of water. But suppose we were preparing one for pickling and put a fresh cucumber into brine, we should find it soon become limp and wrinkled as water was withdrawn from it by the strong salt solution. When two solutions are separated by a membrane which permits the passage of water, the stronger of the two tends to draw water from the other until the concentrations of each are equal.

MILLIONS OF MINUTE PORES

The soil water contains salts in solution, but it is much weaker than the sap of the root-hairs, and so water passes through their walls into the plant. The reverse would happen if the soil were watered with brine; water would be drawn from the plant and it would wilt.

Root-hairs are extremely important to plants. They are present in large numbers, so that the total absorbing area of the plant's roots is probably about equal to that of the leaves above ground. Normally we see them rarely. They are in such close contact with the soil particles that when a plant is uprooted and the soil shaken off they are torn away. For this reason when transplanting is done care must be taken to keep a ball of soil adhering round the roots, and to shade the plant for a few days to prevent excessive evaporation before the new root-hairs have grown to replace those which are sure to have been lost.

Plants, like all living things, are continually losing water. Sometimes this appears as

liquid drops, as may be seen on the tips and margins of some leaves in early morning after a warm damp night. But most of the water passes away from the leaves in the form of vapour. As a rule it is given out largely from the lower leaf surface. Examination with a microscope shows that here the skin of the leaf is perforated by minute pores. Although so tiny they are present in enormous numbers; there are as many as eleven millions on a medium-sized cabbage leaf. Through them nearly all the water vapour passes, for the rest of the leaf is covered by a thin film that may be likened to a waterproof varnish.

To some extent loss of water can be regulated. Each pore is surrounded by two sausage-shaped cells. If these lose water, as when the plant begins to wilt, they change their shape and in so doing come closer together and shut the opening.

TREES AND RAINFALL

A surprising amount of water vapour is given off by forest trees, and its effects are not inconsiderable. It has been calculated that two and a half acres of leafy beech wood lose forty thousand gallons of water daily. This means that the air just above the canopy of leaves will be kept cool and damp, and clouds are more likely to deposit their moisture there as rain. This will drip slowly through the leaves to the soil, where it can be gradually absorbed.

When, as so often has happened, virgin forests are ruthlessly felled over large areas and not replanted, the rainfall is likely to be reduced. When sudden storms occur the bare soil will not be able to take all the water at

THE PLANT KINGDOM



HAROLD BASTIN

WHY LEAVES ARE GREEN

Cells with the granular bodies containing the pigment known as chlorophyll.

once and there may be floods, while if the land slopes steeply the soil may be washed away.

With the water, the root-hairs also allow to pass in small quantities of the essential minerals present in the soil, especially the sulphates, nitrates and phosphates of sodium, calcium and magnesium. There is a possibility that plants obtain from the soil minute traces of unknown substances, which may be compared with the vitamins essential to animal welfare. The presence of these may account for the greater value of farmyard manure and leaf-mould as compared with artificial fertilizers.

RETURNED TO THE SOIL

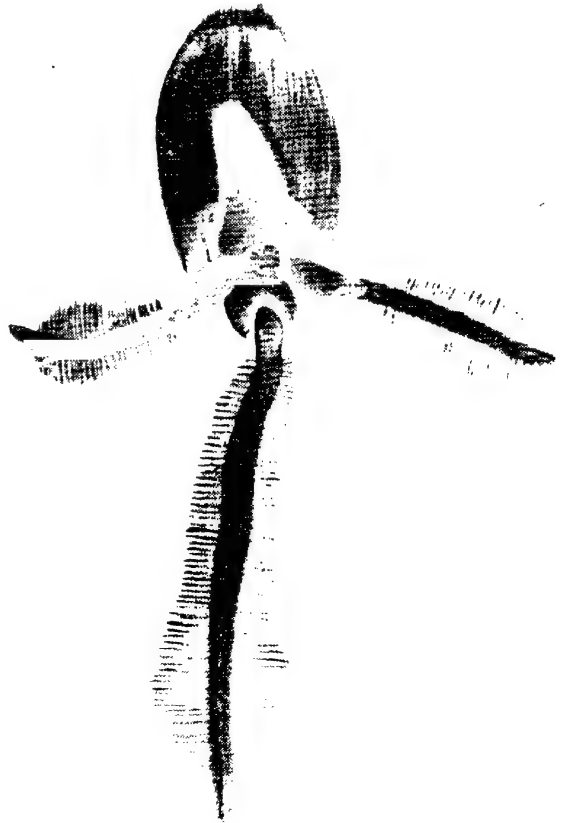
Under natural conditions the roots of dead plants remain in the ground, the leaves and stems fall there, and in the end much of the substance is returned to the soil to be used again by other plants. But in agriculture large crops are being continually lifted, and it is necessary to manure the soil to keep up its fertility. Different plants vary in their requirements. Thus the sea kale likes a dressing of common salt, wallflowers and pinks need lime. It is therefore profitable for farmers to rotate their crops, growing on one piece of land in successive years plants which have different wants.

A good plan for vegetables would be potatoes, followed by peas, root crops and cabbages. The tobacco demands potash in quantity; before plant physiology was understood the original Virginian plantations were worked out

and prosperity passed to new soils. Now the American farmers do not attempt to grow tobacco on the same plot every year, but sow successively wheat, grass, clover, maize and tobacco, returning the waste stems and leaves of the latter to the soil.

PLANT CHEMICAL FACTORIES

The pea family, which includes such valuable plants as clover, beans, lucerne and lupin, is remarkable in that its members actually enrich the soil with nitrogen instead of depleting it. On their roots will be found little nodules which are inhabited by bacteria. These have entered originally from the soil and, like others there, are able to take up the nitrogen of the air and manufacture chemical compounds from it. In some way these are passed on to the pea plant, which has thus no need for nitrogenous soil fertilizers. When it dies and decays a store of nitrogenous food is released for other plants. With few exceptions the pea family are



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DELICATE ROOT-HAIRS

Germinating wheat grain, showing root-hairs which allow water and minerals to pass into the plant.



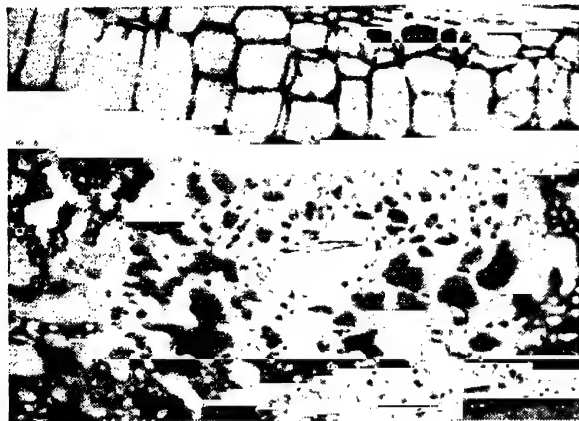
WHAT HAPPENS WHEN FORESTS ARE DESTROYED

FOX

A surprising amount of water vapour is given off by forest trees. When, as so often happens, virgin forests are ruthlessly felled over large areas and not replanted, the rainfall is likely to be reduced. Above: a dust storm in the United States. Below: freshly-planted farm land being whirled away. The reckless destruction of forests has also much to do with the causing of floods. Liability to erosion and other wearing-away processes which help to silt up a waterway is increased.

the only plants which can use the vast stores of nitrogen in the air, and they do so only by the agency of bacteria.

The good effect of a crop of this type had been known for centuries, though the reason was not understood. It has now been found that actually when the plants are still growing they pass out nitrogenous compounds to the soil, and so the benefit is at once appreciated by neighbouring plants. Pasture land is much improved if sown with a mixture of grass and



HAROLD BASTIN

CELLS IN A LEAF

Highly magnified section of leaf showing the diversity of cells and tissues.

clover. The food value is considerably increased and nitrogenous fertilizer for the grass is unnecessary.

Although its store of nitrogen is not touched, the air furnishes a vital part of the plant's food. Carbon dioxide, a gas which we know best as the bubbles in soda water and cider, is present in very small amount, about one in four hundred parts. In sunlight or suitable artificial light the green parts of plants are continually taking in this carbon dioxide and giving out oxygen in its place, exactly the reverse of what happens when we breathe.

In the plant the gas is decomposed, the oxygen released, and the carbon combined with the hydrogen and oxygen of water to form a sugar. To split carbon dioxide into its elements in the laboratory requires a large amount of energy. In the plant it is done through the agency of the green pigment chlorophyll, which in some remarkable way is able to trap the energy of light and use it to build up sugars with effortless ease from water and carbon dioxide. We should be astonished if a glass of soda water, left in the sun, was found to have

become a sweet liquid, yet this is the transformation continually being made by the green plant.

Generally the sugar is at once converted into solid granules of starch, which are stored for future use. When a plant is preparing for a resting period food may be stored in special organs, such as swollen bulbs and tubers or seed leaves. That is why the leaves should not be cut from bulbous plants until they have finished their work and are yellowing, otherwise they will not have made sufficient food to build up a good flowering bulb for the next season.

WASTE OF THE PLANT LABORATORY

Not all the sugar is converted to starch. Some may be used to form oils and fats, especially in seeds, and more important still are the proteins which are necessary for building new tissues. In them carbon, hydrogen and oxygen are combined with the nitrogen taken up by the roots to make substances of complex structure. Many of the plant products which are of use to us, such as resins and aromatic substances, and various drugs, seem to be the waste materials of the plant laboratory. All but the sugars can be manufactured without sunlight.

The tremendous activity of the leaf factories may be realized when one is told that a rough estimate of the annual world increase in dry weight of plants is eighty billion pounds. It is on this that the lives of the whole animal kingdom depend. Much of our own food is vegetable in origin, while the animal portion of it can be traced in a very few steps back to plant material. Thus milk, butter, beef and mutton are built up from grass and clover, and hens' eggs are a product of their cereal foods.

FOOD PRODUCERS OF THE SEA

Even in the sea it is the same. The herring principally feeds on little shrimp-like creatures, and the latter on the tiny microscopic floating plants which are extremely numerous in the upper waters. There they find sufficient light to manufacture sugar and build that up into other substances. Without them the sea would be barren; there is, it is true, a fringe of seaweeds round the coasts but hardly any animals eat them. The little plants, whose presence we hardly suspect, are the real food producers of the sea. From their store of sunshine the cod and halibut derive the vitamin A which they store in their livers, and with which

children are dosed in winter to keep them in healthy growth.

It is safe to say that without green plants the animal life which we know could never have evolved. Without chlorophyll too the plant world could not exist. It is true that certain bacteria can obtain their foods by breaking down iron and sulphur compounds and so are independent of light and of the products of other forms of life. Organisms might have developed further on these lines, but they would have been very different from the forms of life we know on this planet.

TRAPS FOR SUNLIGHT

The need for light dominates the life of green plants. Flattened leaf surfaces provide the necessary large area to trap the rays. It can often be noted how leaves on the branch of a tree arrange themselves to form a mosaic, so that there is as little overlapping and shading as possible. So effective may this be that hardly anything can grow under a beech in summer.

Stems generally turn towards the brightest light and so place the leaves in a favourable position. In hedgerows we find climbers, such as clematis and bryony, scrambling up and up through the branches of hawthorn and hazel to the open. Many low-growing plants, such as primroses and bluebells, flower and complete their growth in the spring before the hedges and woods are thick with leaf to shade them. Fortunately plants vary in the amounts of light they require. One of the most modest in its demands is the aspidistra, which will generally survive, if not grow, in the darkest corner of a room.

When improved illumination has been installed in caves, such as those in the Cheddar Gorge and at Kent's Cavern, Torquay, a film of green has appeared round the lights, where previously was a barren surface. Young ferns gradually developed. Probably the spores were carried in by air currents and were able to grow as soon as there was sufficient light.

SOME PLANTS LIKE SHORT DAYS

The length of the daily exposure to light bears an interesting relation to the flowering of plants. In the tropics day and night are roughly equal all the year round. In higher latitudes a twelve-hour day only occurs at the equinoxes (March 21 and September 22); in summer the days are long, in winter short.

Some plants are unaffected by this. The tomato, though a native of the tropics of South America, will flower and fruit in the British Isles from the longest days down to one of only eight hours, though outdoors frost will check its activities before these short days are reached. So it can be profitably cultivated in glasshouses in the winter.

On the other hand, violets will only flower if the days are less than twelve hours long; normally they flower in spring but will do so at midsummer if the plants are covered for



HAROLD BASTIN

LITTLE CHEMICAL WORKS

Nitrogen nodules on the roots of the red clover. They are inhabited by bacteria from the soil.

part of the day. *Coreopsis*, a common garden plant, needs a long day; it can be flowered in winter in a greenhouse with electric light to lengthen the day. Quite a weak light is sufficient.

This reaction to length of day has to be considered when new plants are introduced to Great Britain. Thus *Cosmos* daisy is a short day plant. Early sowing will not make it flower faster; often the right day length is not reached until soon before the frosts take the plants. However, seedsmen are successfully



LEAF MOSAIC

HAROLD BASTIN

The house-leek arranges its leaves so as to take full advantage of the light.

finding strains which respond to a longer day and so flower earlier.

The formation of underground tubers is also related to day length. Dahlias and artichokes develop them when the day is short. Carrot requires a fourteen-hour day to make the roots swell, onions form normal bulbs with a fifteen-hour day. Fortunately for us our potato is indifferent to length of day. Its ancestors in South America only form tubers in a twelve-hour day, and in England might not be ready to dig before the frosts, which are fatal to them, have arrived.

PLANTS GIVE HEAT

For their living activities plants require a supply of energy; as in animals this is released for them by the breaking down, or digestion, of food materials. It may be likened to the burning of coal, which generates the power to drive a steam engine.

We have seen that in sunlight the green leaf gives out oxygen in return for carbon dioxide, but all living parts of plants are continually performing the reverse exchange of gases, just as we do when breathing. Oxygen is taken in, used to break down complex substances, and the carbon dioxide, which is produced in this process, is given out. Even so apparently lifeless an object as a dried pea is respiring, though in its dormant state the fire of life burns so slowly that perhaps not more than one cubic centimetre of carbon dioxide would be given out in three years.

In plants the substance broken down to

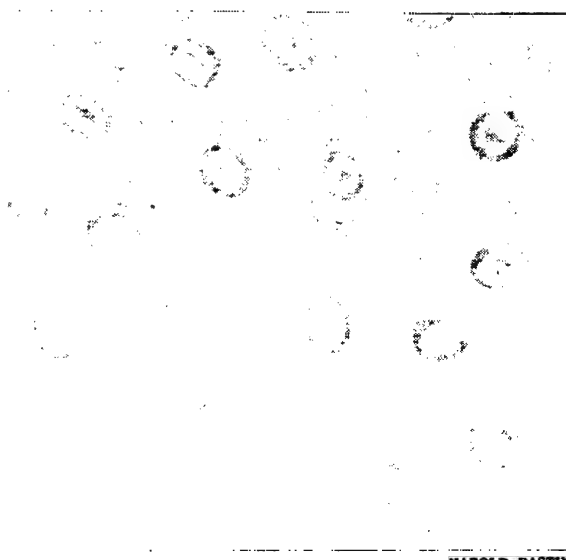
release energy is a sugar; carbon dioxide, and the water which also appears, are the waste products and are passed out. A certain amount of the energy appears in the form of heat, though we rarely notice this. Sometimes after a fall of snow it can be seen that it melts first round the plants, which peep up through it.

The sugar which the green leaf manufactures in sunlight is generally stored as starch grains, and these must be broken down again before the sugar can be used as food material. There are present in living cells certain ferments, which work on complex substances in a way which the chemist may find hard to imitate.

LIVING FERMENTS

The sight, thought or smell of appetizing food causes glands in our mouth to pour out saliva, a fluid containing a ferment which reduces starch to sugar; the gastric juices of the stomach digest proteins, such as meat and cheese. Plant ferments are similar. Thus there is a powerful starch-splitting ferment in sprouting barley, which gives the sweet taste to malt (grains dried after sprouting). Fresh pineapple juice can digest proteins. If jellies are flavoured with it they will not set because the ferment digests the gelatine (a protein). There is no action if the juice has previously been well boiled, for such heat destroys the activity of all these living ferments.

The constant exchange of gases between plant and atmosphere is not ordinarily obvious.



HAROLD BASTIN

HOW PLANTS BREATHE

In sunlight the green leaf gives out oxygen in return for carbon dioxide.

Plants left in a bedroom at night will not use enough oxygen to spoil the air, certainly not if the window is open, as it should be. But where there is a mass of actively respiring material, such as sprouting seeds, as in a ship's hold when grain has become damp, then quantities of carbon dioxide may be produced. This gas is heavy and so will tend to accumulate over the seeds, and may prove very dangerous to an unwary approacher.

Roots need oxygen for their respiration as much as do the parts above ground. So plants often do not thrive in heavy soils with few air spaces between the particles, and may be lost in winter if the ground is waterlogged for some time. Rolling lawns compacts the soil; there is greatly improved growth if the grass roots are aerated by spiking the ground systematically.

GAS RESPIRED BY APPLES

Some of the mangroves, which live in swamps on tropical seashores, have special breathing roots, which stick up out of the water instead of growing down into the ground. Their tissues are very loosely constructed so that gases can readily pass in and out.

Stored fruits, such as apples, are continuously



MANGROVES

They have special breathing roots which stick up out of the water instead of growing down.

M.O.L.—G



MEASURING THE BREATHING OF APPLES

Stored fruits, such as apples, are continuously respiring while still alive and ripening.

respiring while still alive and ripening. The little spots in the skin are special pores of loose tissue, the rest of the skin being not easily penetrated by gases. If the fruit is kept without sufficient ventilation the accumulated carbon dioxide causes the injury to the flesh known as "brown heart." It is interesting that if the concentration is kept below the danger limit the apples are unharmed, and there is a delay in ripening which can be most profitable to growers, for it means that fruits can be put on the market long after their normal season.

Storage at low temperatures in an atmosphere enriched with a certain amount of carbon dioxide is commercially successful in Great Britain for Bramley's Seedling and some other apples and is also used in ships' holds. By



HAROLD BASTIN

TRAPS FOR INSECTS

Frond of bladderwort, showing the numerous insect-trapping bladders that open inwards only.

1935 it was shown that pears could be kept in this way well into the next summer, and the development of gas storage is proceeding as fast as research workers can determine the right conditions for different fruits.

INSECT DIET FOR PLANTS

Mention of the gas respired by apples leads one to recall the observation made in 1932 that the presence of ripe apples in a potato clamp retarded sprouting of the tubers, and so assisted in their preservation. One knows the delicious scent of an apple loft. Apparently one of the ingredients of "apple air" is a minute amount of the gas ethylene, which is present also as an impurity in illuminating gas. It is this which checks the sprouting of the potatoes, but on the contrary it hastens the ripening of picked fruit, such as bananas, young apples, oranges and lemons, and is used for this purpose in America.

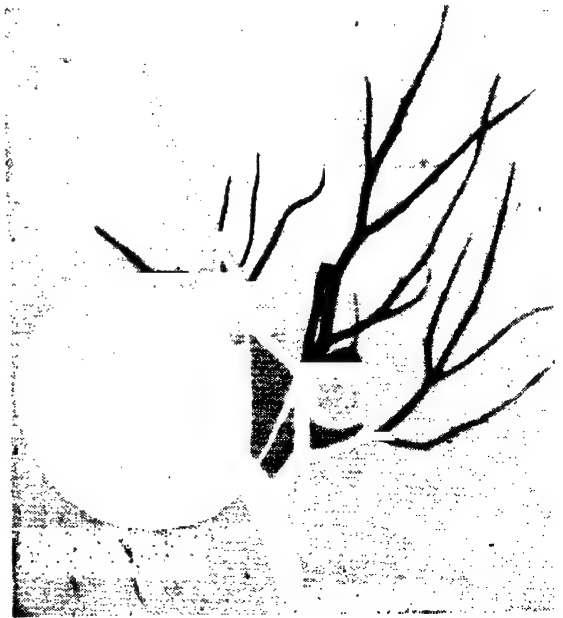
A small number of plants, most of them living in boggy places where supplies of nitrogen are often deficient, are an exception

to the general rule, for they have adopted a partially animal diet, consisting principally of small insects. However, they still contain chlorophyll, and can manufacture some food for themselves.

SUNDEW'S STICKY TENTACLES

Perhaps the best known is the sundew (*Drosera*), a pretty little bog plant, whose reddish leaves are covered with glistening sticky tentacles. If a small animal touches the leaf it is held fast; quickly the tentacles bend towards it and cover it, pouring out a secretion similar to our gastric juice. The ferments partly digest the prey and the resultant liquid is absorbed. The sundew can be made to digest fragments of meat or egg white, but it will have nothing to do with bits of glass, cinders or paper, from which it could not obtain nutriment.

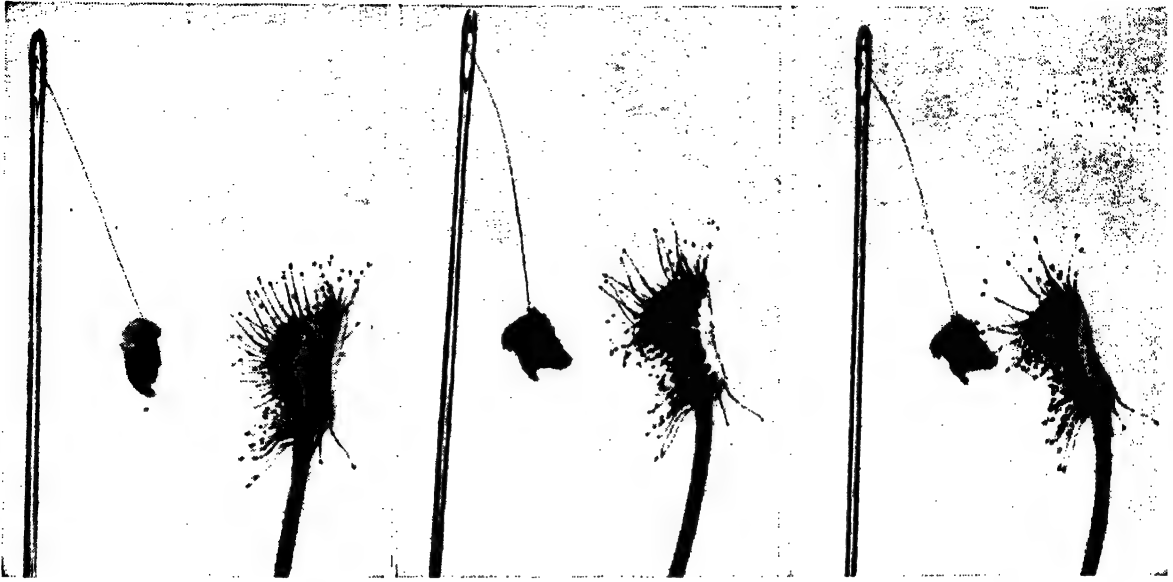
Also found in bogs is the butterwort (*Pinguicula*) with its pretty mauve flowers. The sticky leaves are a yellowish green with incurved edges. Tiny glands on the upper surface secrete a ferment which digests any insect that is caught. Milk in which a leaf is placed will be turned to curds and whey just as by the rennet from a cow's stomach.



HAROLD BASTIN

BLADDERWORT'S CONDEMNED CELL

A bladder of the bladderwort magnified to show the little door at one end.



HAROLD BASTIN

BOG PLANT THAT DIGESTS MEAT

A remarkable series of photographs showing how a sundew leaf responded to the near presence of an atom of meat suspended by a hair from a needle. The sundew is a pretty little bog plant.

Of a very different type is the bladderwort (*Utricularia*) which is sometimes found in ponds. Among the very finely divided leaves are little bladders with a door at one end, opening inwards only. By some means the plant pumps water out of them and the walls collapse. The trap is then set. If some tiny swimming creature touches certain sensitive bristles round the entry, the door flies open and the side walls spring out. The change of shape causes water to be sucked in and the animal is drawn in with it. The door snaps back, and as it cannot be pushed open from within the prey is secured and later digested.

MISTLETOE IS A PARASITE

Despite their extra food supply the insect-eating plants of Great Britain do not wax fat; indeed they are far from conspicuous. Much more striking are some tropical forms, such as the pitcher plant (*Nepenthes*). The tip of the drooping leaves is prolonged into a tendril bearing a brightly coloured pitcher, complete with lid and a strengthened rim. Nectar is produced round the edge. Insects come to sip it, but as they walk in they find the surface becomes very slippery, and they are led to the bottom, where there is a copious secretion of liquid. Into this many slip and are drowned, and it seems that the plant absorbs the products of their decay. The pitchers of some

forms may be as much as eighteen inches long, with liquid sufficient to drown a small bird.

Interesting though they are, the flowering plants which prey on animals are but an insignificant fraction of the whole. We may be glad that there has been no such development as the imaginary orchid of Mr. H. G. Wells's story, whose aerial roots fastened themselves like leeches to their grower and sucked his blood.

A small number of plants obtain their food from the activities of their neighbours. Compared with these they may be said to be degenerate, though they are only behaving as do many members of the animal kingdom. Mistletoe parasitic on apple trees is a familiar sight. It draws on the latter's sap, but its yellow-green leaves manufacture most of its food. Yellow rattle and the little eyebright are found in poor pastures. Although they are green they only develop normally when their roots have become attached by little suckers to those of grasses. There is no doubt of the purpose of these organs.

WORLD'S LARGEST FLOWER

More dangerous is the dodder, which is not uncommonly parasitic on gorse. It has no roots to draw supplies from the soil, but the slender stems, like a mat of red cotton, twine round the host, fastening suckers deep into its

in the shade of beech woods, obtains nourishment from the decaying leaf mould. However, it can only do this indirectly. The tangle of roots, from which it derives its name, is clothed with a mass of fungal threads. These pour out their ferments over the leaves, digest them and then absorb some of the products. Something is doubtless passed on to the plant, but the position of the fungus is one of insecurity, for where it penetrates into the cells of the orchis it often is digested itself.

The roots of most of Great Britain's forest trees have fungal threads similarly associated with them, which may help in their nutrition. When the fungal companion of the birch fruits above ground it proves to be the beautiful scarlet fly agaric. Illustrators of fairy tales are much given to introducing this mushroom into their pictures, but they rarely put it in its proper place under a birch tree.

A French fresco dating from 1291 depicts the Tree of Life as a fly agaric with Eve after having eaten of its forbidden fruit—a highly dangerous proceeding.

HAROLD BASTIN

WITHOUT LEAVES

Dodder fixed to a stem of heath, on which it is parasitic. It has thread-like stems and no leaves.

tissues. Varieties which prey on crops do much damage and are hard to stamp out.

In the most advanced parasites the green colouring matter has been completely lost and the leaves are mere scales or missing. Perhaps the most remarkable is *Rafflesia Arnoldi*. It grows in the jungle of Sumatra, parasitic on the roots of a vine. The vegetative organs are reduced to underground threads, but the flower, with warty brown and white petals, surpasses all others in size, being quite a yard across and fifteen pounds in weight. Beautiful it is not: endowed with precisely the smell of tainted beef, it attracts swarms of carrion flies.

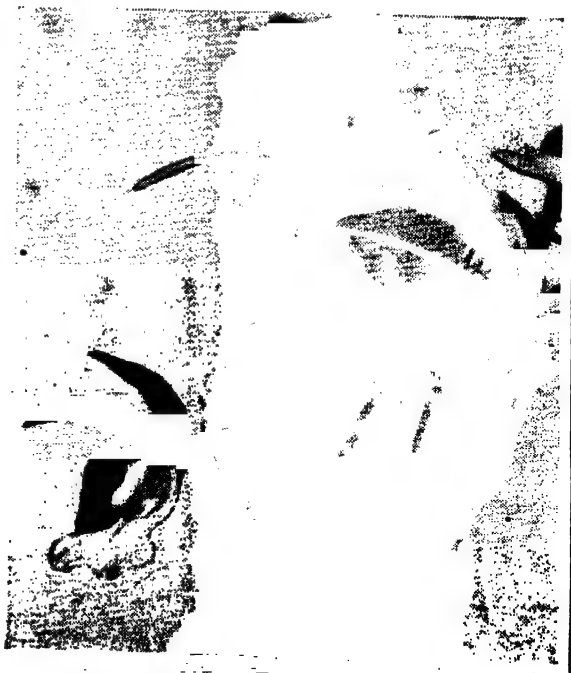
There are also a few flowering plants which, though colourless, are not parasitic, but live on the dead remains of organisms. The queer looking and evil smelling bird's nest orchis (*Neottia*), which is one of the few plants found



HAROLD BASTIN

SCARLET FLY AGARIC

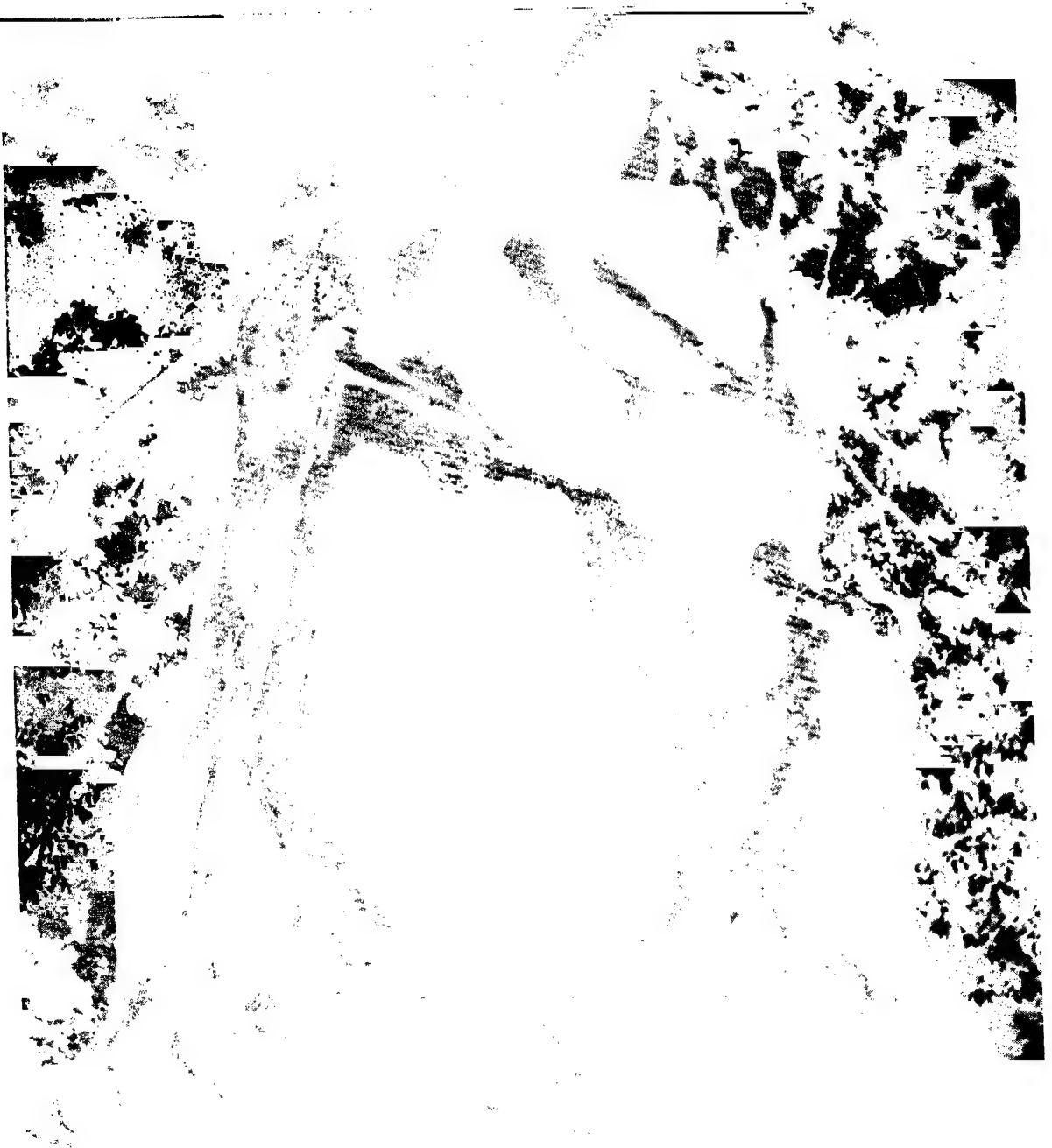
The beautiful fungal companion of the birch, beloved of illustrators of fairy tales.



PLANT WONDERS

HAROLD BASTIN

Top: pitcher plant ; pitcher with insects creeping towards the fatal entrance. Below: mistletoe on apple tree ; epiphytic orchid, which roots on bark.



FOX

TREES THAT CRUSH MAN'S HANDIWORK

Of venerable age, this tree in a jungle of Sumatra has grown to such a tremendous extent that its powerful roots are slowly clamping the granite walls of the temple in a death-like grip.



WORLD'S MOST WONDERFUL PLANT

HAROLD BASTIN

The Venus fly-trap, which Darwin designated "the most wonderful plant in the world." When an insect is caught the plant slowly absorbs the nutritious matter in its victim.

THE REPRODUCTION OF FLOWERING PLANTS

THE span of life of flowering plants varies greatly, from the chickweeds and groundsel, which can grow, seed and die in a few weeks, to the tremendous "Big Trees" (*Sequoia*) of California, some of which are certainly over fifteen hundred years old and have even been estimated at four thousand years.

Many plants are of annual duration, growing and fruiting in summer and passing the winter as seeds. Most of the crop plants of Great Britain conveniently are in this group. Some, such as carrots, are really biennials, not flowering until the second season, but for the purpose of the consumer the first year's growth is sufficient. A great many trees and herbaceous plants fall into the class of perennials and may live a number of years, though some do not naturally have a very long life. Flowering brooms do not usually last more than about

eight years; gardeners have been known to suspect enemies of poisoning these plants when they have really reached the end of their term of years.

When death, natural or otherwise, comes there must be a means of carrying on the generations. Increase may take place by a form of division. Perhaps it is simplest of all in the bacteria, where the cells at a certain stage divide into two equal halves, a process which is sometimes repeated as frequently as every twenty minutes. In the yeasts the products are unequal; a tiny nipple-like cell is budded off from the parent but soon grows to equal it. This kind of reproduction is known as vegetative, for though it occurs in some animals, as when the broken-off arm of a starfish grows into a complete new animal, yet it is much more characteristic of plants.

Many cultivated plants are constantly increased by means of "cuttings" — leafy shoots as in fuchsia and pink, which root readily in damp, porous soil; portions of root as in horse-radish; and in begonia cut leaves. This is done by man's agency, but something similar occurs naturally. In the "Hen and



HEN AND CHICKENS FERN

So called because complete miniature fern plants are produced from the old fronds.

Chickens" fern (*Cystopteris bulbifera*) tiny leafy buds develop on the fronds and root when they reach the ground. In the related "Walking Fern" the tips of the fronds regularly arch over and root and so it spreads to some distance. Shoots of blackberry will do the same.

Many plants send out creeping stems—above ground as in strawberry runners, or below as in perennial sunflower—from which new shoots arise at some distance and form their own roots. Bulbs and tubers are other familiar methods of vegetative reproduction.

This type of increase is often highly successful, as witness for example the invasion of untended grasslands of the dry type by the spreading underground stems of the bracken; the vast crops from "seed" potato tubers; the groves

of the seedless orange produced by grafting. In 1906 there were in existence only three bulbs of the well-known narcissus "Bath's Flame"; thirty years later it was estimated that there were about nine and a half millions, all descended by vegetative reproduction from the original three.

In 1842 the Canadian waterweed (*Elodea*) first appeared in England. Only plants of one sex were present so seed could not form, but vegetative reproduction by portions of the plant breaking off was so rapid that in a relatively short time it was choking the waterways; now there is probably no river in the country which does not contain it.

PARENTAGE BRINGS DEATH

However, it does seem that sometimes continued vegetative reproduction weakens the vigour of the plant, and it is anyhow true that nearly all plants possess, like animals, a means of sexual reproduction. In flowering plants this precedes the formation of seeds. Often it leads to the death of the parent, as in annuals. In order to prolong the life of their plants gardeners pick off the "dead" flowers: these are very often those which are setting seed and are really very actively forming new living units. After long years of slow vegetative growth the century plant (*Agave Americana*) in a few weeks throws up its immense spire of creamy flowers and after fruiting dies.

Some butterflies never even feed; they emerge from the chrysalis, pair, and with the laying of the eggs their lives are ended. Many examples, from high to low in the scale of evolution, could be drawn to show the truth of Sir J. Arthur Thomson's statement that "In the dawn of life immortality was pawned for love." Shorn of the emotional complications of human parentage, sexual reproduction appears as an unselfish proceeding.

PRODUCTION OF NEW TYPES

Biologically its most important significance is the possibility it gives of the production of new types from the union of two parents with different characteristics, which may be re-combined in their offspring. Thus if a choice pansy is to be preserved, cuttings must be taken; if grown under the same conditions these will repeat exactly the original type. If the seeds it sets were sown, there would almost certainly result a variety of forms, none necessarily the desired one.

The essential feature of sexual reproduction



HAROLD BASTIN

LUXURIANT GROWTH OF THE CENTURY PLANT

The century plant, or American aloe, which after long years of slow vegetative growth throws up an immense spire of creamy flowers, and after fruiting dies. Its native home is Mexico and Central America.

is the union of two distinct male and female elements, from which the next generation arises. The sex-cells are very tiny, and it is rarely possible to see them or their union in flowering plants. Other lower forms of life are more simply constructed, and in them the details are more easily observable. Few objects are more favourable in this respect than the common bladder-wrack, a brown seaweed characterized by the air-bladders on its fronds and frequently found in abundance on rocky sea shores.

SPERMS OF THE BLADDER-WRACK

The reproductive elements are formed in the fat juicy tips. If plants are collected and kept out of water overnight it will be found that slime of two different colours has oozed from some of the tips. The orange contains the male sperms, the other is coloured olive-green or brown by the eggs. As always, the sex-cells are very small, but those fortunate enough to have the use of a microscope can now observe an enthralling biologic drama.

Drops of the slime are added to a little sea-water on a glass slip; even with the naked eye it can be seen that they at once mingle intimately. Under magnification the eggs appear as relatively large, rounded bodies, floating passively. Round each rages a furious commotion as a crowd of tiny sperms besiege it, lashing to and fro the little beating hairs by means of which they drive themselves through the water. As they swim actively over its surface and wriggle against it they even cause the egg to spin round.

ARTIFICIAL STIMULATION OF EGGS

Suddenly all is quiet, the sperms move off elsewhere; that particular egg has ceased to attract them, and we know then that a male element has penetrated into it. The two have become united and the egg is said to be fertilized. It can now begin to divide and produce a new plant. Artificial stimulation of the eggs of the bladder-wrack sometimes induces them to start growth without fertilization by the male, but this never proceeds very far.



HAROLD BASTIN

BLADDER-WRACKS

Fronds of these seaweeds, showing the air-containing bladders by which they are supported in the water.

Particularly interesting is this to watch, for our own origins are not dissimilar. The human egg-cell is a little motionless speck of jelly of about the same size, that is to say just visible to the naked eye. It is, however, sheltered in the body of the mother, into which are introduced the swarms of sperms, again minute bodies swimming actively. It is somewhat humiliating to consider our small beginnings, but there is plenty of food for thought in the problem of how these little globules, almost structureless to our eyes, can grow into such complicated and different organisms.

MALE AND FEMALE CELLS

Like the bladder-wrack, flowering plants have their male and female cells, but they are not so easily seen inside the flower. Typically the latter consists of four different kinds of structures. Outside are the green sepals which protect the rest in the bud stage. Then come the petals, often large and brightly coloured. Within are a number of stamens, delicate stalked structures with heads full of tiny pollen grains which generally look like golden dust.

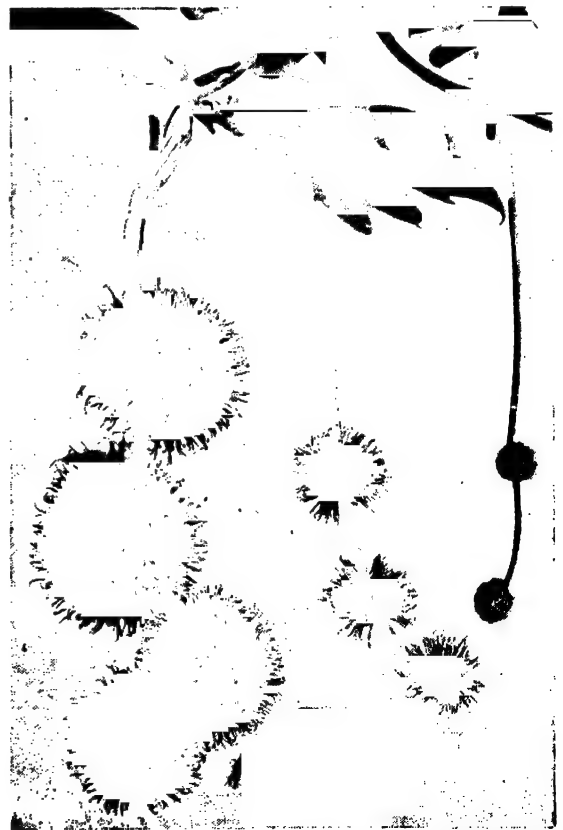
In the centre is the ovary which encloses the embryo seeds. At its tip is the sticky stigma, often borne on a little stalk.

By various means the pollen grains are conveyed to the stigma, where they adhere. There they are stimulated to put out each a little tube, which grows down into the ovary and makes its way to an egg-cell. Then from the tip of the tube the male cell emerges and fuses with the female; from their union a seed grows.

FERTILIZING PARTNERS

At least one pollen grain must be provided for each seed, more to allow for wastage. Compared with their size the pollen grains put out very long tubes, and it is remarkable that they are able to find their way to the right spot. In crocus flowers they have to go from the feathery stigma perhaps four or five inches down to the ovary, which is underground close to the corm. On their journey they are nourished by cells secreting a sugary substance.

A glance round a garden will show what varied types of flower there are. One may



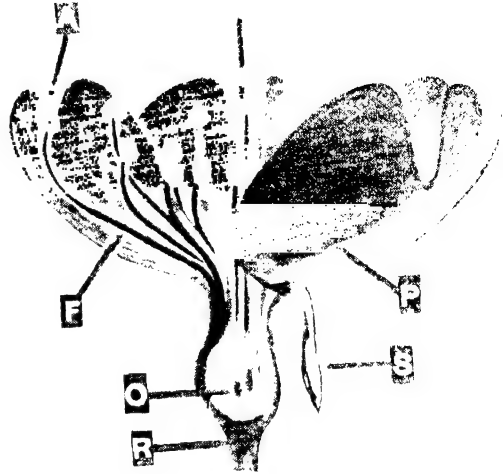
HAROLD BASTIN

FLOWERS AND FRUITS

Left: fruits of the plane tree. Middle: male flower. Right: female flower.

see the open cups of poppy and anemone with their clusters of stamens, the funnel-shaped convolvulus, the nasturtium with a long spur, evening primroses and night-scented stock which do not unfold their petals until dusk, pansies prettily marked like kittens' faces, the butterfly flowers of sweet pea, the daisy-like marigold, and perhaps here and there among the wealth of colour and beauty of form the inconspicuous and unwelcome flowers of the prolific nettle and groundsel.

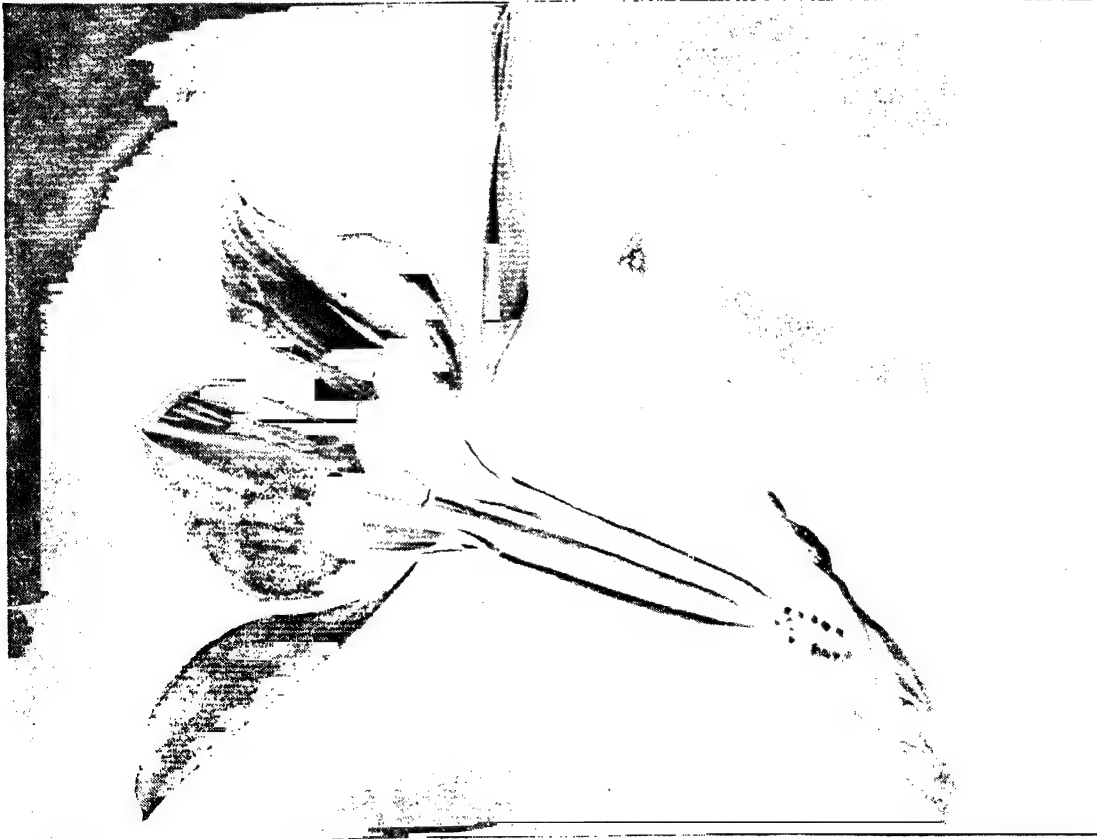
The differing characters of these and other flowers can largely be related to the methods by which the pollen is conveyed to the stigma. Often the two are so close together in the flower that it might be imagined the mere trembling in the breeze would effect it, and indeed this sometimes happens. But it seems to be a general rule in nature that better results are obtained if the pollen comes from another flower (of course of the same kind) and cross-pollination takes place. Many flowers are so



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PARTS OF A FLOWER

A—Anther of stamen. F—Stalk. G—Stigma of pistil.
O—Ovary. P—Petal. S—Sepal. R—Receptacle.



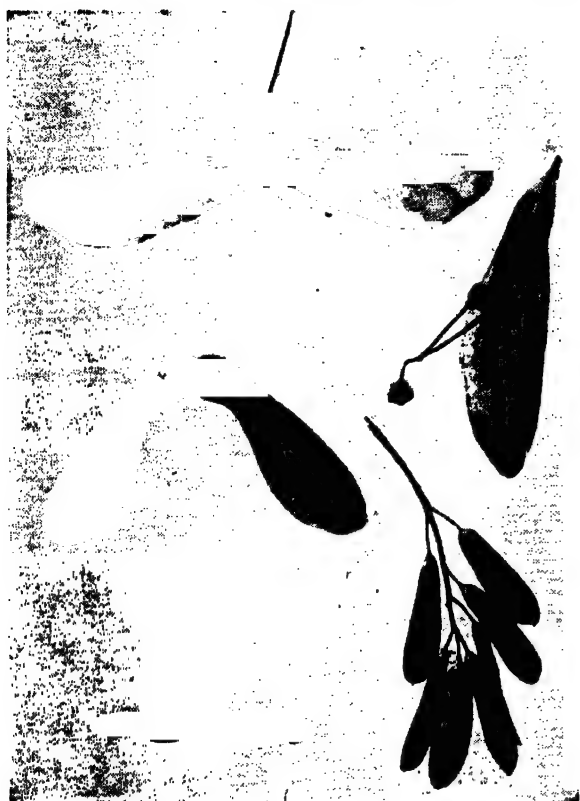
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EMBRYO SEEDS IN THE OVARY

The flower of a narcissus bisected so as to show the essential organs. Note the ovules or embryo seeds in the ovary close to the sheath of the stalk.

constructed that it is impossible for them to fertilize themselves, either because of the relative positions of the organs or because stamens and stigma are not ripe at the same time.

Some cultivated fruit trees are completely self-sterile and are so particular in their matings that only a few other varieties can fertilize them. Thus if the black cherry Early



WIND-CARRIED FRUIT

Top; Norway maple. Below (left) sycamore; (right) lime. Bottom (left) field maple; (right) ash.

Rivers is planted it must have a suitable partner, such as the yellow Governor Wood. If there is room for only one cherry in the garden it must be the self-fertile Morello. If a Cox's Orange Pippin does not fruit it may not be the fault of the weather, the tree or the soil but only that a suitable pollinator is not present. So it is recommended that orchards should be planted with a number of different varieties of apples, so that there will be in flower at the same time types which can fertilize each other.

The light dusty pollen of many trees and grasses is carried by the wind from plant to plant. With this haphazard method there is

bound to be great wastage, and large quantities must be produced. Sufferers from hay fever, to whom the grains are intensely irritating, find grass pollen so widespread in June that it is difficult to avoid getting it into the nose.

The pollination of the great majority of flowers is related to the visits of insects, especially bees, but also wasps, flies, moths, butterflies and others. Pollen adhering to the body of an insect may be carried from one plant to another, and if it reaches the stigma may enable good seed to be set. The animal plays no conscious part in the transfer; its visits are only occasioned by the search for food. Pollen forms a good source of proteins and fats, while many flowers also provide a secretion of nectar, a sugary fluid which after partial digestion in the bee's crop is pumped up again as honey.

GATHERED IN POLLEN BASKETS

Neither of the two groups of insects and flowering plants appeared until a relatively late stage in evolutionary history. It is remarkable how the structure of many of their representatives has developed together so that the one act serves the different purposes of both organisms.

Bees are by far the most important flower visitors. Pollen is collected by the jaws and front legs, as well as being picked up by the feathery body hairs. It is gathered up by the hind legs and finally pushed up into the pollen baskets formed by a hollow, walled in by curving hairs, on the outside of the shin of each hind leg. Humble-bees can be seen with bulging loads of pollen as big as their heads. Nectar is sucked up by a tubular structure which can be protruded at will from the mouth.

BEES ATTRACTED BY COLOUR

We may wonder how the bees manage to find the flowers. Although many appear conspicuous to us, we must remember that other animals may not have the same senses as we. Dogs for instance can appreciate different degrees of brightness, but are almost colour blind. Bees can distinguish blue from yellow, but red appears dark to them. In their visits they show a marked preference for blue flowers, yellow coming next in favour. Their sense of smell is much the same as ours, that is to say it is not very acute and nothing like so strongly marked as in dogs or in some moths, where the male can scent a female a mile away.



INSECT VISITORS OF FLOWERS

HAROLD BASTIN

Top (left): Painted lady butterfly on a thistle head ; (right) hover fly stealing pollen from a wild rose.
 Bottom (left): Humming bird hawkmoth feeding on a garden nasturtium ; (right) blue butterflies on the cross-leaved heath.

Thus the bee will first be attracted by the colour of the flower, scent will be an additional guide as it approaches, while when quite close there may be petal markings, such as a light eye, scattered spots or rays which will aid recognition of particular types of flowers.

Hive bees have evolved a remarkable kind of



HAROLD BASTIN

PLANT AND INSECT PARTNERS

The yucca can only be pollinated by its moth Pronuba, whose caterpillars live only on the plant.

sign language by which they communicate news of the flowers. When a worker bee (sterile female) returns to the hive from a rich source of nectar she disgorges the honey, and then dances round in circles. She is excitedly watched by others which crowd round and "sniff" at her with their feelers. Then she departs.

The dancing has conveyed to the others that there is plenty of nectar to be found, while the particular flower scent clinging to her has given them a clue where to search. Besides this they may find later that she has left her own mark on the flowers visited by exuding over them a little "bee-scent" from special glands in the

tail. If supplies are poor there will be no dancing and no more workers set out.

When the news is that pollen is abundant the dance is of quite a different type, rather a swaying to and fro, while the pollen grains which are carried have their own distinctive smell.

TRANSFERRING THE POLLEN

As an example of a flower visited by bees we may take the foxglove. Its spire of spotted bells is a conspicuous sight, and humble-bees visit it from dawn to dusk in fine weather. They alight, push their way into a flower and protrude the sucking organ to draw up nectar from the bottom of the tube. The four stamens stand pressed against the upper side of the tube and pollen from them will be rubbed off on to the bee's back. The stigma stands in much the same place as the stamens, but is slightly more forward, so that is likely to be the first to touch the insect and pollen from another plant may then stick to it. Of course, when departing, the bee might transfer the flower's own pollen to the stigma, but this is not likely because the latter is usually not ripe until the stamens have shed their pollen. If insect visits are prevented, seed is not set.

The tale of the fig and its wasp has been told many times. The cultivation of the Smyrna fig in the United States proved impossible until the right insect was brought there to effect pollination.

PLANT AND MOTH PARTNERSHIP

An even more remarkable example of plant and insect working together is probably that of the yucca and its moth *Pronuba*, for the flower can only be pollinated by this moth, while its caterpillars live only on the yucca. It forms a handsome rosette of stiff, pointed leaves with large branches of creamy bell-like flowers, which are scented at night. The female moth, after being fertilized, visits a flower and makes a big ball from its pollen; then she flies to another and deposits her eggs in its ovary, climbs up and places the pollen on the stigma. Fertilization is ensured, the seeds develop and with them the caterpillars, there being sufficient seeds to feed the latter and leave a few to ripen. Then the caterpillars fall to the ground, pupate there and the moths emerge next year just at the time the yucca flowers open.

There are many other wonderful arrangements, but one must admit that the serpent sometimes enters into this Eden. In many

flowers the nectar is at the base of a long tube; theoretically only certain insects are able to reach it, and in so doing will pollinate the flower. The snapdragon can only be pollinated by large humble-bees whose weight is sufficient to open the closed lip of the flower. But other shorter-tongued bees have learnt to bite through the tube farther down and then reach the nectar from the side. The robbers do not touch either stamens or stigma, and so the mechanism of the flower is defeated.

WORK OF HUMMING BIRDS

It is astonishing to watch butterflies and moths visiting flowers and putting out tubes for sucking nectar. The tubes may be as long as their bodies, but can in an instant be coiled up like a watch spring. Moths mostly visit long-tubed flowers such as honeysuckle, which are strongly scented at night and generally pale coloured or white.

Butterflies live up to their proverbially roving disposition; they flit from convolvulus to pink and then perhaps to something quite different. The pollen they might carry from one to another would be of no use.

There are a few unusual pollinating agents. In the tropics many large, brightly coloured flowers, particularly red ones, are pollinated by the tiny humming birds as they hover in front of them and insert their long thin beaks in search of nectar.

Every year in the autumn there are reports of these birds appearing in England. They are doubtless confused with the humming bird hawk-moth. As the latter's long proboscis is pushed into a flower the wings flutter at great speed; the hairy body with flattened tail has the shape of a bird's and only the antennæ on the head betrays its nature.

GIANT ARUM'S PRISONERS

A few plants, many of the arum type, have an extremely unpleasant odour and livid colour. Flies are attracted to them as to rotting flesh. The wild arum is of this kind, though its smell is mild compared with many of its relatives. There is a green sheathing spathe with a cylindrical structure inside terminating in a purple spike. Small insects fly down the tube, past a ring of downward pointing hairs, and find themselves trapped at the base. The hairs prevent them from flying out, and although there would be room for them to crawl out they cannot apparently do so. At the bottom



DR. BERTRAM TRUSTEES

FLOWER SIX FEET HIGH

Amorphophallus titanum, a giant arum with a flower about six feet high. Its stench is almost insupportable.



SEEDS AS TRAVELLERS

A seed of the spotted orchid weighs only one-fifteen-thousandth part of a grain. It may travel many miles.

of the spike are female flowers which may be pollinated if the flies have visited another arum. In a few days the sheath withers and the captives can emerge, in so doing becoming dusted with pollen from the male flowers, higher up the spike, which are now ripe. One giant arum, *Amorphophallus*, has a "flower" of this type about six feet high. Its stench to us is almost insupportable.

POLLINATED BY SNAILS

The domestic aspidistra, a native of the forests of Eastern Asia, sometimes produces quaint brown flowers, lying just above the surface of the earth. It is said that in nature they are pollinated by snails crawling over them.

Occasionally, man has to perform the marriage ceremony. So gardeners dust their peach flowers with a brush full of pollen in case insects do not enter the greenhouses. The

cultivation of the vanilla orchid was introduced into Java, but the humming birds and bees which normally pollinate it were not there. When the flowers open, women go round pollinating as many as three thousand flowers each a day. The seed then sets and the scented pods form.

SEEDS THAT EXPLODE

A few exceptional plants can set seed without fertilization. This happens frequently in the hawkweeds. Cucumbers and some apples require to be pollinated before the fruit will develop, but the latter will continue to grow without seeds forming. A cucumber with seeds is no use for eating. This behaviour is not particularly desirable in apples for the shape of seedless fruits is not good.

A flowering plant usually produces many seeds, but such is the competition and wastage that the numbers of the different species remain



WILLOW-HERB OR FIRE-WEED

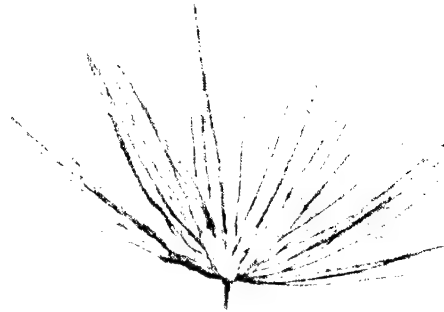
The seeds of the willow-herb bear tufts of light hairs that enable it to be carried by air currents.

more or less the same. Overcrowding would soon choke them if the seeds were not dispersed some distance from the parent. A few plants are able to do this for themselves. On a hot summer's day one may hear the dry gorse pods suddenly splitting in half and thereby flinging the seeds several feet through the air. Incidentally, ants are said to find them attractive and may carry them still farther away. Ripe fruits of the touch-me-not balsam are in such a state of tension that if touched lightly they explode violently and the seeds shoot in all directions.

DISPERSAL BY WIND

The most usual agency of dispersal is wind. The seeds of orchids are very minute and float in the air for long distances, possibly hundreds of miles. So numerous are they that Darwin calculated that the great-grandchildren of a single plant of the spotted orchis would, if they all lived, cover the whole surface of the earth with a uniform green carpet. So light are the seeds that each weighs only one-fifteen-thousandth part of a grain.

Heavier seeds may be so constructed that they do not fall at once to the ground and are carried some way by air currents. The seeds of the willow-herb bear a tuft of light hairs.



NATURE'S OWN PARACHUTE

The parachute which supports the seed of the cat's-ear and secures its dispersal by air.



FALL OF THE LEAF

A plane tree in the act of shedding a leaf, exposing the bud of its successor.

It has been noted several times that building sites in the heart of London have been invaded by shoots of this plant; the seeds must have been transported some distance. In America the willow-herb is known as the fire-weed, not on account of its colour, which is a somewhat puce pink, but because it appears so frequently on ground where the original vegetation has been destroyed by fire.

WINGS OF THE SYCAMORE

The hairy parachutes of the fruits of dandelion are well known, while the lightness of thistle-down is proverbial. The much heavier fruits of sycamore have two big wings and spin through the air. Seedlings often spring up in gardens some way from any tree.

Some fruits are carried by water. The coconut which we eat really corresponds to the stone of a plum. When shed it is surrounded by a thick fibrous coat, from which coir is derived. If it falls into the sea it can float many miles, and so we find the coconut palm is widespread on all tropical coasts.

Animals, too, play an important part, carrying seeds either inside or outside their bodies.



HOOKED FRUIT

HAROLD BASTIN

The fruit of the grapple plant hooks itself to any passing beast. The pod splits open when ripe.

The hooked fruits of goosegrass catch easily in furry coats and may be rubbed off later some distance away. Wading birds carry away the seeds of water plants in the mud adhering to their feet. Squirrels bury acorns and nuts and often forget their stores, which may later produce seedlings.

A plant which itself buries its fruit is the monkey- or pea-nut. Few of the millions who eat them realize that they have developed underground. The plant is low and bushy with small vetch-like flowers. After fertilization a stalk below the fruit elongates, grows down and buries the young fruit in the soil. It will not develop if kept in the light.

CARRIED INSIDE BIRDS

Juicy brightly coloured fruits, such as haws, make a special appeal to birds. The seeds inside them have a hard coat and pass unharmed through the digestive system. They may be carried a considerable distance before they are dropped. "Hurrah!" wrote Darwin to a friend, "a seed has germinated after twenty-one-and-a-half hours in an owl's stomach. This . . . would carry it God knows how many miles."

The stork's-bill is so called because the long awn or beard attached to the seed pod resembles at a distance the beak of the bird after which the plant is named. When the seed falls to the ground the awn acts as a kind of auger, assisted by a number of flexible hairs that help to keep the seed in position. The varying conditions of the atmosphere make it twist and untwist, so that eventually it bores its way into the ground and the seeds germinate.

Man plays an important part in carrying

seed to new places. Alien plants are often accidentally introduced from abroad with seed of other plants, or amongst cargo, ballast or packing. Many, such as the winter heliotrope, have escaped from gardens but have become thoroughly well established here in the wild. Sometimes well-meaning people try to beautify the countryside by sowing seed of some favourite cultivated plant. Usually the experiment fails, for conditions in a garden, where the plants are carefully nursed and competition eliminated by weeding, are quite unnatural. The practice is viewed with disfavour by botanists.

MENACE OF THE DANDELION

Occasionally it is successful. Every year the Northumbrian Roman Wall is brightened by the purple flowers of a little Spanish plant, *Erinus alpinus*. People have liked to imagine how some Spanish legionary centuries ago brought it there to remind him of home. In reality a local clergyman planted it and, conditions being to its liking, it has flourished.

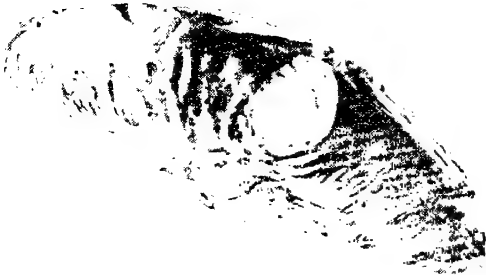
Not uncommonly alien plants find the new surroundings so favourable, that with their



HAROLD BASTIN

CARRIED IN FUR

Another hooked fruit which is carried in the fur of beasts and thereby ensures wide distribution of the seeds. It may be taken a considerable distance.



HAROLD BASTIN

PLANT GLIDER

Seed of Zanonina, which glides from the parent plant and sometimes is carried a considerable distance by air currents in its native Java.

natural enemies absent they increase by leaps and bounds. Daisies, plantains and dandelions are as common in North American lawns as in those of Great Britain, but all originated in Europe. The dandelion has spread so successfully as to be known as the yellow peril. In various parts of the world homesick Scottish colonists have grown and cherished plants of thistle and so added to the troubles of later years. Brambles, introduced into New Zealand, have become a gigantic menace.

USEFUL BUT OBNOXIOUS NETTLE

Many an alien plant flourishes on the banks or in the waters of England's slow-flowing rivers and canals. Mention has already been made of the Canadian pondweed, which first made itself known in Great Britain in Market Harborough some eighty years ago. Although it has never been known to produce seed in the country of its adoption, it manages to



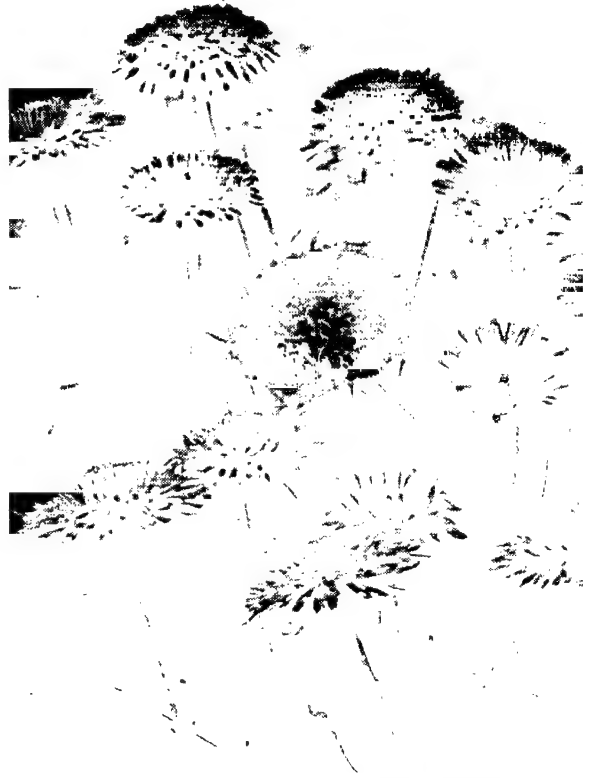
HAROLD BASTIN

LIKE SHAVING BRUSHES

Fruits of the corn-bluebottle plant. They resemble miniature shaving brushes.

flourish exceedingly and with even greater persistence than the proverbial bay tree.

A plant which is a native of Africa and India made its appearance all unsuspected in an English canal. Presumably, it had found its way by means of a consignment of Egyptian cotton sent to a mill. So far as is known it had secured a foothold on European soil only once before, in northern Italy. There it had been chaperoned by East Indian rice. Other



HAROLD BASTIN

KNOWN AS THE YELLOW PERIL

Dandelions are as common in North American lawns as in those of Great Britain. All originated in Europe.

importations have included algae from America, again due in all probability to a bale of cotton, though on this occasion from the southern United States.

Nettles are by no means in the good books of the agriculturist and the gardener, yet they serve quite a number of useful purposes. Many species of birds which live on insects find their favourite food on the flowers and leaves, and the latter also afford excellent cover for their nests and eggs. The shade they give likewise secures a certain amount of moisture in the ground where they are rooted. This is appreciated

by snails, which are eaten by birds that do not appreciate an insectivorous menu.

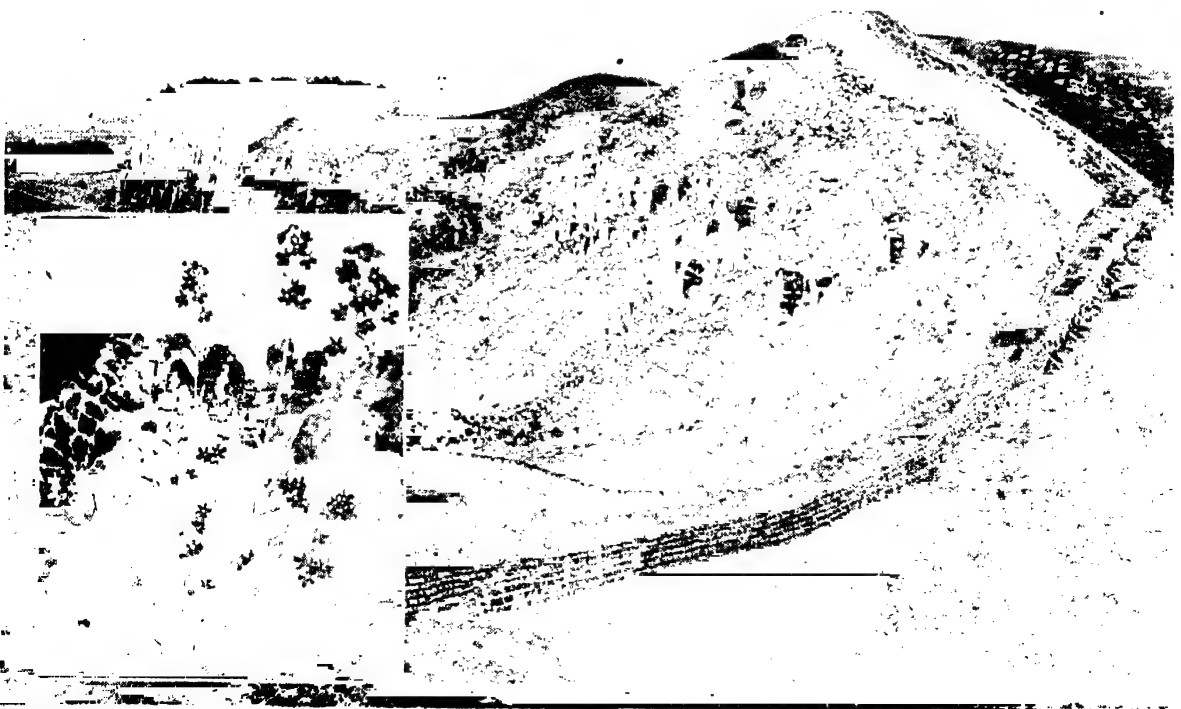
The caterpillars of various butterflies, including those of the red admiral, peacock and small tortoiseshell, and the tiger moths find the leaves of the common stinging nettle to their liking. Perhaps the most curious use to which this weed, at once so obnoxious and so useful, is put is for stopping leaks in barrels. The juice is rubbed between the staves, and when hard has the same effect as caulking on the wooden deck of a ship.

Many millions of acres in the north-western parts of the United States are covered with a plant called Australian saltbush. For long it was regarded as a weed that served no useful purpose; a mere encumberer of the ground on which it thrived all too well. As the earth was arid and nothing else seemed to thrive on it, little or no attention was paid to the plant until a rancher, finding by accident that his sheep took to it readily, decided to make an experiment and allow a flock to graze on it. The result was amazing, for he found that the animals flourished exceedingly. They produced

considerably better wool and better mutton.

Another plant with good and bad qualities from a human point of view is spartina or rice grass. It is of considerable value on muddy flats, such as the sea invades and by slow degrees wrests from the land, because it helps to consolidate the soil and renders it valuable grazing land. It appeared apparently from nowhere in the neighbourhood of Southampton Water. Unfortunately, its excellent behaviour is not evident in navigable waterways, where it becomes a menace. Some years ago about a hundred cuttings of spartina were planted on the sea side of a wall which appeared to be doomed by the constant pounding of the waves. Although only a few of the plants survived the ordeal, they spread so rapidly that both the wall and the farm it protected were saved. The shrubby sea blite (*Suaeda srutacosa*) is also an important beach strengthener, and there are kindly plants which bind together the sandhills.

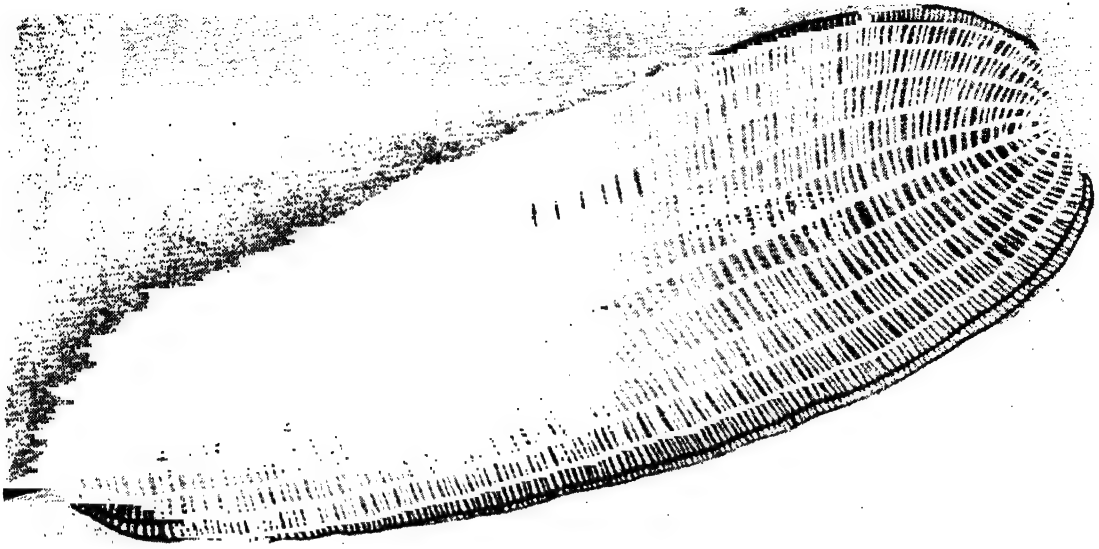
"Nature," it has been said, "is conquered by obeying her, and man is but her puppet until he learns the lesson of obedience."



HAROLD BASTIN

SPANISH PLANT ON THE ROMAN WALL

The Northumbrian Roman Wall is brightened by the purple flowers of a little Spanish plant called Erinus alpinus (inset). It was not brought by a legionary centuries ago, but planted by a local clergyman.



WORLD'S MOST REMARKABLE LEAF

HAROLD BASTIN

The exquisite leaf of the latrice plant, a native of Madagascar, which grows under water. The leaves grow to a length of some eighteen inches in the largest specimens, and consist for the most part of veins.

PLANT ANATOMY

PLANTS, like animals, are built up of a living substance, known as protoplasm, and its products. Protoplasm appears to be generally a semi-solid jelly; we can analyse it chemically and find its composition, but no one can put these substances together again and create living matter.

The plant body consists of many tiny units called cells; these when living contain sap surrounded by a layer of protoplasm in which is a special body, the nucleus, which controls the activities of the cell. Each is enclosed by a firm wall of a substance called cellulose. Cell walls make up much of the mass of plant tissue; human beings are unable to digest the cellulose, but the bulk it provides stimulates the movements of the intestines.

Cells may be considered the bricks of which the plant body is composed. At certain growing regions, particularly the tips of the roots and shoots, existing cells are continually dividing into two and producing new units. At first they are roughly cubical, but as they grow they develop on different lines according to the parts they have to play.

Some change their shape little. The pulp of fruits is formed of cells of this type. Besides cellulose there is present in the walls a gelatinous

substance known as pectose. It is this which causes jam to set; it is most abundant in under-ripe fruit.

Other cells may become stretched out and develop thick walls. These form fibres, which strengthen the plant. When they are very long and strong, as in stems of flax and hemp, they are important to man.

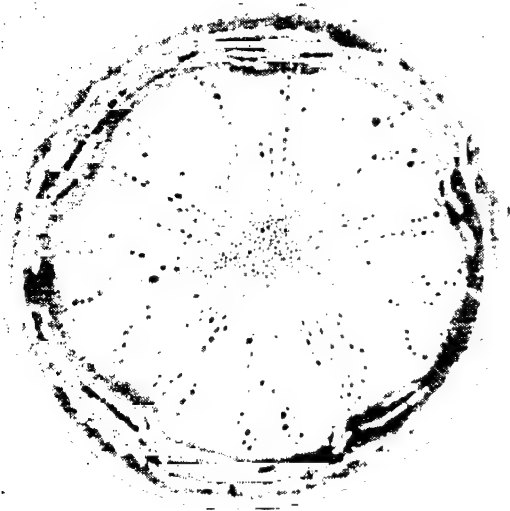
Much of the bulk of stems and roots, the trunks of trees and the veins of leaves is made up of wood. The cells become drawn out lengthways, their living contents and the cross-walls between them disappear, so that long tubes are formed, as when drain-pipes are laid end to end. The walls are altered to a woody substance.

Growth in trees is more rapid in spring than in summer, and larger wood elements are formed then. The sudden transition from the close summer wood of one year to the open spring wood of the next is very marked, and shows up as a ring when a trunk is cut across. By counting the number of annual rings the age of the tree is found.

In the tropics, where there is little difference between the seasons, growth proceeds evenly and rings are hardly noticeable. Sometimes growth is slow, giving close, heavy wood such

as ebony. In the balsa tree it is rapid and the wood elements are so light that the wood is more like cork. It is used in cinema studios to make the woodwork for knockabout comedies; a blow with it will not break any heads, but it can easily be shattered.

The tubes formed by the wood elements conduct water and mineral salts from the roots to the leaves. Exactly how they are pumped up, sometimes many feet, remains more or less of a mystery. In the spring at least there



SECTION OF YOUNG OAK

By counting the number of annual rings when timber is cut down the age of a tree is found

are also sugars in the rising sap; in the American sugar maple it is worth while collecting it.

Outside the wood is a tissue whose elements are formed in the same way from elongated cells placed end to end, but the cross walls do not disappear. They are perforated by tiny holes. It is thought that materials manufactured by the leaves pass down through these. Whether they make their way down to the roots through the wood also is a matter which is not yet decided.

Stems are often surrounded by a layer of cork. The cells here are compactly arranged and their walls contain a substance which makes them waterproof. They have no living contents. Potatoes have a corky skin which prevents them from losing water and also helps to keep fungi from attacking the food within.

The cork oak produces a great mass of tough elastic cork which is stripped off at intervals and finds many uses. In the birch there are

alternately layers of thick- and thin-walled cork cells. The latter tend to split away from the others, and so thin layers of tough corky bark peel off naturally. The American Indians used them for making canoes.

Space does not permit of much consideration of the structure of leaves. Among the simplest are those of the Canadian pondweed (*Elodea*), which are composed of a few layers of brick-shaped cells. The most noticeable of their contents are numerous little discs, or chloroplasts, which hold the green pigment. Incidentally they are continually being jostled round and round the cells, for the protoplasm here shows active streaming movements. Most of the cells of other green leaves contain similar chloroplasts. It is in their bodies that sugars are formed in sunlight.

DEVELOPED IN CONES

It is often easy to peel off a piece of the skin from the under surface of a leaf. When one looks down on this through a microscope one can see the tiny scattered pores through which gases and water vapour pass in and out. Each is surrounded by two sausage-shaped cells.

The preceding pages have been devoted mainly to the plants which are most familiar to us, those which bear flowers and seeds and make up more than half of the plants known. Seeds are also found in the group of trees that includes pines, yews, cypresses, cycads and others, whose male and female organs are developed in cones. The male cells are produced from pollen grains; in the pine these are provided with two little wings to buoy them up. They are carried to the female by wind. The seeds are not enclosed within an ovary but are borne on the open conc-scales.

The group produces some very valuable timber trees, many being quick growing, with straight trunks and wood of even texture.

GIGANTIC FERNS

Besides the seed-plants there is a host of others of a simpler type. These never form seeds, that is to say large reproductive units produced as a result of fertilization and fitted to undergo a resting period, but have very varied methods of reproduction.

Ferns are found over much of the world; those of Great Britain are generally not very imposing. Bracken, of world-wide occurrence, attracts attention by the area it covers. Under a well-grown royal fern (*Osmunda*) a tall man

can shelter, but this magnificent plant is now rarely allowed to survive in the wild in England.

In the tropics ferns are far more luxuriant. Some are like trees, a crown of fronds uncoiling at the top of a stout trunk. Fern-like plants were very abundant millions of years ago when much of our coal was laid down. Still preserved among it are the fossilized trunks of giant relatives of the present-day insignificant club-mosses.

ONE-CELLED SPORES

On the back of a fern frond one often finds little groups, apparently of brown dust. Here masses of tiny one-celled spores are produced. They are very light and may be carried far by the wind. If a bottle or jam-jar is inverted in damp soil it is very probable that ferns will in time appear under it, for the spores seem everywhere abundant.

They do not at once produce a fern plant, but instead a delicate little leaf appears whose under surface produces sex organs. From some burst out masses of tiny sperms, provided with



HAROLD BASTIN

LEAVES OF SIMPLE STRUCTURE

The leaves of the Canadian pondweed are composed of a few layers of brick-shaped cells.

beating hairs. The female, or egg-cells, are well protected, each being at the base of a flask-shaped structure. The sperms swim to them in the water which collects underneath; the fertilized egg grows to a new fern plant.

Lower in the scale of evolution are the mosses and liverworts. The latter are generally inconspicuous and restricted to damp places, but mosses are found all over the world, on rocks and dry land, in bogs and on tree-trunks, from the Arctic to the tropics.

MOSES AS PIONEERS

Generally they grow in tufts of closely packed stems, covered with tiny leaves. At the tips of the shoots sex organs may be found. Though the details can only be seen with a microscope the groups are obvious in the common hair-moss (*Polytrichum*). The male organs make a little orange-red cluster surrounded by green leaves, the form of the whole recalling a daisy.

The sperms must have a film of water in which to swim to the groups of egg-cells, again housed in flask-shaped structures. The fertilized egg grows out to form the moss capsule,



HAROLD BASTIN

CONIFEROUS TREES

Top (left): Spruce and Douglas fir; (below): Scotch pine and Austrian pine; (right): Larch. Their male and female organs are developed in cones.

a little globular or urn-shaped body on a delicate stalk, not unlike a poppy seed-head. It is full of spores, which produce new plants.

Mosses are important pioneers in the colonization of bare ground, but we have little contact with them. One of the best known is the bog-moss (*Sphagnum*) which forms soft masses of bright green over dangerous mires. The dried fronds have the power of absorbing moisture



HAROLD BASTIN

"FERN SEED"

Underside of a magnified fern leaf, showing groups of tiny one-celled spores.

very rapidly and have been used for wound dressings.

One moss (*Schizostega*) has the power of so collecting up light with its tiny cells that it appears to be luminous. It favours damp, dimly-lighted places, such as caves or rabbit burrows, and is said sometimes to have deluded miners. When it is carried out into the light the film of moss can no longer be seen and the false nugget is just a lump of earth.

The writer recalls visiting the stone tomb of some pre-historic Cornishman. With the body a golden beaker had been found many years ago and presented to Queen Victoria. Now the fairy gold of moss accompanies the chieftain's spirit, shining with a lovely greenish radiance on the walls of the hollow.

Among the algæ are seaweeds and the growths which form pond scum, together with many microscopic forms which include the simplest plants known. Nearly all live in water. Some consist of but a single cell; in others chains of cells form simple filaments or threads, while in many seaweeds these are woven together to form quite a solid body.

The tiny green algæ of ponds only reveal their beauty under the microscope. One of the loveliest is *Volvox*, whose cells form a hollow sphere, clearly visible to the naked eye. Each cell has a pair of beating hairs, and so the ball makes stately progress through the water.

WITH A FLINTY COAT

Diatoms are important members of the group. In the mass they are brown. Each consists of a single cell with a flinty coat, most delicately sculptured. Countless millions of them float in the upper waters of the oceans and provide food for many marine animals.

Among seaweeds the green pigment is often masked by red or brown. One red weed, the Irish moss (*Chondrus crispus*), contains much gelatinous substance. It is collected and dried by the Aran islanders and still finds some uses.

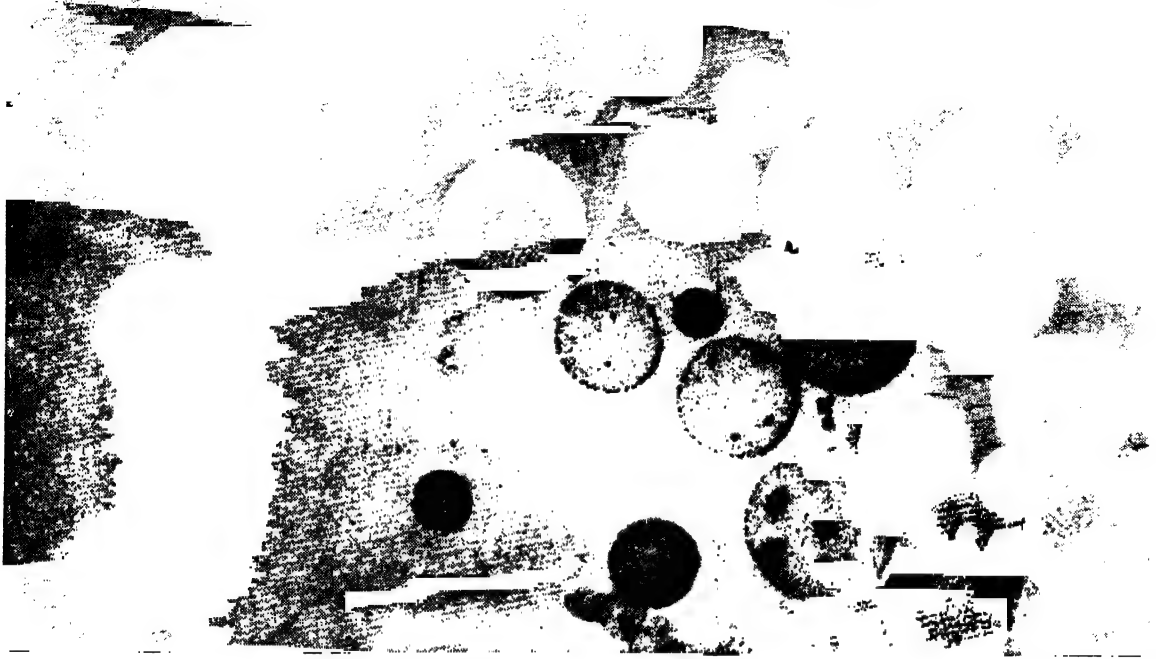
The brown weeds include the large kelps or oarweeds (*Laminaria*). They have a remarkable power of taking up the minute traces of iodine in sea water and storing it in their tissues. The plants make good soil fertilizers, while a certain amount of iodine is still extracted from them commercially.

Some red seaweeds take large amounts of lime from the sea and deposit it in their tissues so that they become hard as coral. They are found on the shores of the British Isles as a pink coating to rocks and stones; in tropical waters there are forms which help to build up reefs.

EVOLVED FROM ALGÆ

Sexual reproduction in the bladderwrack has already been described. There is great variety in the reproductive processes of the algæ, but nearly always the male and female cells are shed into the water and fusion takes place there.

One very large group, the fungi, is devoid of the green pigment chlorophyll. Included in it are the mushrooms and toadstools, moulds and blights, mildews, rusts and smuts, yeasts and bacteria. Although many are harmless, the presence of others is the cause of most plant and animal diseases.



HAROLD BASTIN

FLOATING COLONY OF ALGÆ

Volvox, one of the loveliest of the tiny green algæ to be found in ponds. Each cell has a pair of beating hairs which enable the ball to make stately progress through the water.

They seem to have evolved at a very early stage of existence from algæ which lost their pigment and came to obtain food in various peculiar ways. The vegetative body usually consists of very fine branching threads, which may sometimes be woven together to make a solid body, as in the mushroom. It must be noted that the real mushroom plant is the fine underground threads, which when mixed with dung form "spawn"; the mushroom we eat is only the fruiting body.

FORTY MILLION SPORES A DAY

In many fungi there are no traces of a sexual process, but in almost all, tiny spores are produced in great quantity. A sunbeam reveals that the air is full of dust motes, but it cannot show the hosts of fungal spores and bacteria always present too; even many thousand feet above the earth a few can still be detected. Small wonder when we learn that a common mushroom produces forty million spores a day.

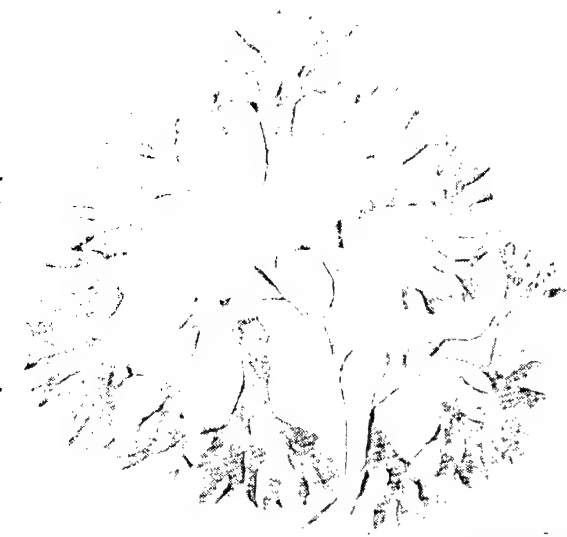
Many fungi live on dead organic matter, mushrooms on dung heaps, toadstools on tree stumps, black mould on bread, green mould on jam and cheese, in fact there is very little

that some form will not find to its taste. Usually the substances have to be broken down in order to provide the simple compounds they need. Ferments are poured out and the threads then absorb the products of digestion.

RUSTS AND SMUTS

It is a small step from feeding on dead to living matter. Many have become parasitic, taking their food from the bodies of other plants and animals and thereby causing much damage. There is indeed hardly a plant which is not liable to be attacked by one or more kinds. There are various rusts and smuts on cereals, potato is affected by blight and wart disease and many others, plum by silver-leaf, rose by mildew and leaf-spot, and so the catalogue goes on. It is not an exaggeration to say that something like one-tenth of the crops are lost owing to their activities.

The fungus responsible for the damping-off of seedlings can vary its behaviour. It is at first parasitic on them, feeding on the stems just above the ground; then when they have been killed it lives on their dead tissues.



HAROLD BASTIN

IRISH MOSS

The edible red seaweed which contains gelatinous substances used in the preparation of food for invalids.

A few fungi live on animals. Goldfish are sometimes seen with a fine white mould growing on the gills; it will choke them in time but can easily be killed by dipping the fish into salt water. Ringworm and thrush in human beings are caused by fungi.

Yeasts are fungi with a very simple structure. The body is but a single ovoid cell, of which there are many millions in an ounce of compressed yeast. It can vary its mode of life according to the conditions. When supplied with food, in the form of sugar and plenty of oxygen, it proceeds as in a normal plant, converting it to water and carbon dioxide and using some of the energy released.

KILLED BY THEIR OWN PRODUCT

But if oxygen is absent, as at the bottom of a vat of liquid, it can live in a more extravagant way, known as fermentation, only partly breaking up the sugar and leaving as waste products carbon dioxide and alcohol. We might perhaps compare the process to a child eating the icing off a cake and throwing the rest away.

The action of yeast has been employed by man for centuries. If added to a stiff mixture of flour and water it digests the starch; the carbon dioxide produced is held by the elastic dough and the bubbles formed by the gas make a spongy texture, which gives palatable and digestible bread.

Also important is the production of alcohol

from sugary liquids. Wild yeasts are present in the air and on the surface of most fruits; if these are crushed, water added and all left to stand, the yeasts soon multiply; they will ferment the natural sugar and if more is added they will continue "working" until either the food is all used up or the quantity of alcohol that they have produced kills them.

EXPLOSIVES FROM YEAST

If the brew is bottled before fermentation has finished the carbon dioxide is unable to escape and accumulates under pressure. When the cork is drawn bubbles of the gas rush out and make a sparkling drink, such as cider. In wines the concentration of alcohol is much higher; it is still greater in spirits, which are produced by distilling fermented liquids and collecting the alcohol.

Tiny though the yeast cells are, they must house a veritable laboratory. The ferments which they can secrete will act on many substances besides sugar. How complicated are



HAROLD BASTIN

FOUND IN THE SARGASSO SEA
Gulf weed, a seaweed with an evil reputation because it is found extensively in the Sargasso Sea.

the processes is shown by the fact that in the World War a clever chemist was able, by suitable treatment, to obtain in the fermentation glycerine instead of alcohol. This was a discovery of the greatest importance to his country at a time when there was such a shortage of the fats from which glycerine for high explosives is usually made.

INCREASING BY DIVIDING

Placed among the fungi are the bacteria (sometimes known as germs or microbes), whose structure is even simpler than that of the yeasts. The body is a single minute cell; it may be rod-like or spherical, and in some it is spirally twisted. One-twenty-five-thousandth part of an inch is an average length for these tiny beings. The smallest is only just visible under the microscope. Bacteria are colourless and have so little structure that to show them up it is necessary to stain them with various dyes.

They increase by dividing in half, sometimes as often as once every twenty minutes. There is no sexual process. When conditions are unfavourable the cells may tide themselves over a difficult period by turning into tough-walled spores. In this form they can resist drought and exposure to high temperatures.

Bacteria make their presence known to us by their activities, in particular their feeding methods. There is a whole host upon whose active life the processes of decay depend. They find their food supply in the dead tissues, breaking them down into simpler substances with the aid of their digestive ferments. The waste products of some of them are gases whose smells we dislike, and so decay has unpleasant associations, which it does not deserve. The soil is full of them, busy breaking down the substance of plants and dead animals. In fact, its fertility depends on their presence, for were they (and fungi too) not continually at work the minerals which plants take from the soil would be locked up and the available supplies soon exhausted.

BACTERIA AND TEA

The early stages of decay are utilized in several important instances. The leaves of the tea plant are picked and left in damp piles. Bacteria digest the starch and sugar and then the residue is dried. Green tea is prepared from unfermented leaves, dried at once in the sun; although the brew from them looks colourless it is much more stimulating than black tea.

An unpleasant bitter substance is removed from cocoa nibs by allowing them to ferment a little after shelling. Coffee owes nothing to bacterial action, for the beans are dried as soon as they are picked.

Tobacco leaves are put in layers and begin to decay; the action of different kinds of bacteria produces the varying flavours. Flax stems are steeped in water and the fibres freed from other



HAROLD EASTIN

KILLED BY DEADLY FUNGUS

A house-fly done to death by the spore of the Empusa fungus, which may be seen on the glass.

tissues by allowing bacteria to digest part of the cell walls.

The lactic and butyric acid bacteria cause changes in milk which make it "turn sour." It is important for cheese makers to have the right strain of bacteria at work, for on the activity of particular kinds depend the distinctive flavours of cheeses from different parts.

About eighty years ago, when improvements in the microscope had made it possible to see bacteria clearly, it was noticed that if hay was steeped in water there were soon so many bacteria present that the water became cloudy. It was thought they had been produced in it either by the air or by the decaying matter.

That living bodies should appear suddenly from dead matter seemed quite possible, for it was held that the mud on river banks could

Pasteur also showed that most infectious diseases are caused by the presence in the body of certain bacteria; these are conveyed from one person to another in various ways, and so the diseases spread.

Very often it is not their actual presence which causes trouble. Thus our intestines house a varied collection of bacteria, whose bodies are so numerous that they make up about half of the contents. We feel no ill effects from them. But sometimes another kind, such as the cholera germ, enters and then there is likely to be grave disturbance, for its waste products are a poison to us.

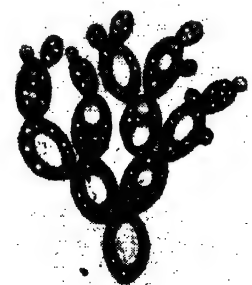
CARRIERS OF DISEASE

Not all the disease-producing bacteria are solely dependent on the human body for their food. Typhoid germs can live in fresh water, where they may be carried with sewage. They may again infect human beings if they enter a water supply or are taken in with shell fish.

It is curious that some people, known as "carriers," can house these bacteria and still be perfectly well. They are very dangerous to their neighbours, for they will be continually passing on the germs of typhoid unknowingly. This applies to several other diseases.

Anthrax bacteria live and multiply in man and many other warm-blooded animals. In the soil, on animal skins and carcasses, they can exist for years in the form of resting spores. Shaving brushes made from infected hair have been known to cause anthrax in the users, the bacteria entering through cuts and at once resuming their activities.

Many bacteria cannot endure long away from their living hosts, though they may not be restricted to one type. Thus the black death and the great plague of past centuries (still known in the East) were caused by an organism whose real home is in small animals such as rats. Sometimes infected



HAROLD BASTIN

YEAST PLANTS

Yeasts are fungi of simple structure which multiply by budding. They are akin to bacteria.

STINKHORN FUNGUS

HAROLD BASTIN

So called because it emits an unpleasant smell that attracts flies which disperse the spores.

breed fishes and frogs. It was even stated by a sixteenth-century scientist that if dirty linen was pressed down with some pieces of cheese, and left for three weeks, adult male and female mice would be produced!

The belief should not be laughed at, for even now superstition and ignorance are still widespread. There are many who are willing for their actions to be guided by what the stars are said to reveal; while magical practices, such as ill-wishing and charming of warts are still performed with faith in their efficacy.

BACTERIA ON MOUNTAIN TOPS

It was the great Frenchman Pasteur who finally proved that if the hay and water were first thoroughly boiled, so that living organisms were destroyed, and kept so that the bacteria in the air could not reach them, then they remained unchanged. Unless special care is taken bacteria from the air fall into the liquid and multiply there, for they are always present, even in the pure air of mountain tops.



HAROLD PASTIN

NATURAL DEFENCE AGAINST ENEMIES

Three twigs of holly picked from the same tree at different heights, showing how the prickliness of the foliage decreases as it grows out of the reach of browsing animals.

animals die, their fleas leave them for another warm-blooded creature and may land on a human being. They live by sucking blood and are very likely to introduce the germs of plague into the bites.

LIVING WITHOUT OXYGEN

Like the yeast plant, some bacteria, such as the type that causes lockjaw, can live without oxygen. These are found deep in rich soil. If they enter a wound they multiply there and their waste products travel round the body in the blood stream, causing terrible muscular spasms.

Fortunately lockjaw is not very common, but all wounds are liable to become invaded by other bacteria, whose products cause blood poisoning and prevent healing. Previous to about 1870 the smallest wound was likely to become poisoned in this way, and the majority of surgical operations proved fatal. It was little wonder when we read that it was etiquette for the surgeon to wear an old frock coat stiff with the blood stains of years, while the same sponge might go the round of all the

patients in a ward, infecting one with the germs from another.

It was Pasteur again who showed bacteria to be the cause of blood poisoning and pleaded for surgical methods which would keep their numbers down. He was ridiculed until Lord Lister heard of his work and put his methods into practice. The surgeon's hands, the instruments, sponges and bandages were soaked with a solution of carbolic acid, which destroyed any bacteria present; it was also sprayed round the wound. As a result only six out of his next forty amputation cases were fatal.

VALUE OF PASTEURIZATION

But carbolic acid and other so-called antiseptics are not particularly good for the living tissues of the body, and so nowadays heat is relied on largely for killing the bacteria. The instruments and the surgeon's rubber gloves are sterilized with steam, the garments and dressings are previously brought to a high temperature, and any water used is boiled.

Pasteur's name is remembered in the "pasteurization" process which much of our



HAROLD BASTIN

PROTECTED BY PRICKLES

By producing bunches of prickles on its main stem the climbing of the honey-locust is rendered impossible.

milk supply undergoes. It was originated for wines and beers. Sometimes they become "diseased" through certain bacteria getting in and spoiling the flavours. No one would drink beer which had been treated with carbolic to destroy bacteria, but Pasteur found that if it was heated for a short time at 55° C. (about midway between the freezing-point and boiling-point of water) the intruders were killed or so weakened that they caused no trouble.

WHERE THE MICROSCOPE FAILS

Milk is the perfect food not only for babies, but for many bacteria, which quickly turn it sour. Pasteurization (at a higher temperature than for wines) does not alter the flavour as does boiling, the food value is little affected and it keeps much longer. But it is by no means free from germs, for the standard of pasteurized milk fixed by law is that it must not contain more than thirty thousand bacteria in one cubic centimetre, that is about half a thimbleful! Diseased cows may have passed the germs of tuberculosis into it, and so all

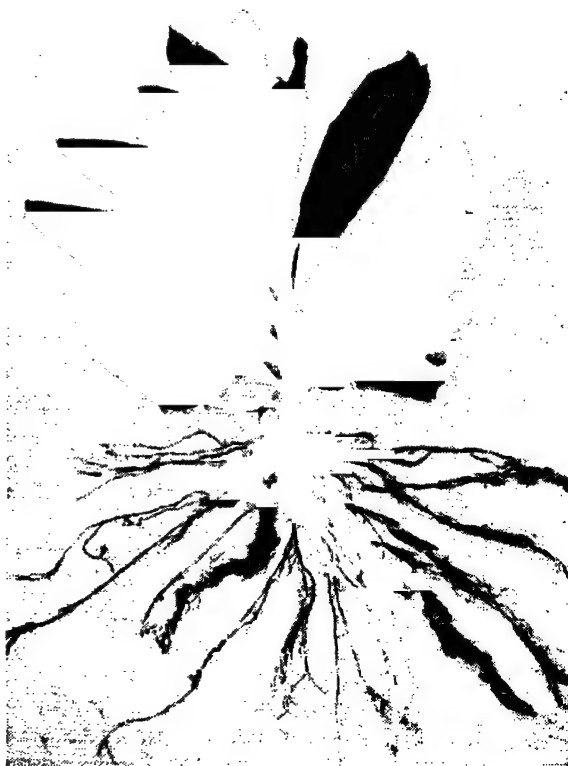
who can afford the extra cost should give children certified milk, which comes from cows proved to be healthy.

There are a number of plant and animal diseases which cannot be attributed to bacterial attack, while if living organisms are the cause they are too small to be seen with any microscope. In plants affected with these so-called virus diseases the leaves become rolled or their green pigment may be partly destroyed so that they develop "streak" or "mosaic." Breaking in tulips is due to a virus which makes the self-coloured petals show white streaks.

REVERSION IN PLANTS

Though attacked plants rarely die, they are not improved in vigour, and if the leaves are the crop, as in tobacco, the trouble is serious. Plant viruses are principally spread by small insects such as aphides (or green-fly) which suck their juices and infect them through the bites. Here is, then, another reason for keeping these pests under control.

The two principal troubles of the black-currant grower are "big-bud" and "reversion."



TOBACCO AS GROWN

A healthy tobacco plant. The leaves when attacked by one of the virus diseases become rolled.

The former is caused by a mite which lays eggs in the buds and destroys the blossoms. When bushes are affected by reversion the leaves gradually change their form and finally are produced so abundantly that there are no flowers. It is thought that this is the plant's reaction to the presence of a virus, which is spread by the big-bud mite. In the early stages the leaf-form is little altered, and shoots for cuttings must be very carefully selected.

FILTER-PASSING ORGANISMS

When the juices of a plant infected with a virus disease are passed through a filter with pores so small that no bacteria can get through them, they are still capable of producing the disease if injected into a healthy plant. So it was thought that living organisms must be present. At the time of writing this seems doubtful, for the virus causing mosaic disease of tobacco and potato has been obtained in the form of crystals.

Smallpox, measles, scarlet fever and possibly influenza are caused by "filter-passing organisms." It remains to be seen whether these too will prove to be non-living substances.



HAMILTON COLLECTION

SWEDISH CLASSIFIER OF PLANTS

Carl von Linnæus (1707-78), whose classification of plants was used until the middle of the nineteenth century.



SPENCER ARNOLD

FAMOUS BACTERIOLOGIST

Louis Pasteur (1822-95), who showed that most infectious diseases are caused by bacteria.

Finally lichens may be mentioned. They are an extraordinary group, for they are not individual plants at all. Each is produced by the intimate union of an alga and a fungus of certain kinds, living together in such adjustment that between them they produce a structure of definite and characteristic form, such as the bright orange lichen often found on old walls.

LICHENS DISLIKE LONDON

Under the microscope it is seen that tiny green algal cells are enclosed in a felt of fungal threads. The fungus seems to keep the upper hand over them, for it alone produces the fruiting body and must derive food from that which the alga makes for itself. The latter receives shelter, moisture and mineral salts and is also enabled to grow in the bleak places which lichens often inhabit, and where normally the alga would not flourish.

On the other hand, the alga is not dependent on the fungus but can live alone if need be. Though the fungus appears to be master in the lichen, its spores can only grow if some of the right kind of algal cells are near by.

Lichens are exceedingly important as

colonizers of bare and stony ground. They may grow slowly, but in so doing they gradually break up rock surfaces and prepare the way for higher plants. They will accept the poorest conditions, but one thing they demand is pure air. In London and other big cities one looks in vain for them.

DYES FOR TWEEDS

The reactions between alga and fungus lead to the production in the lichen of peculiar acids; a number of these provide colouring matters. In the Highlands lichens are still used for dyeing wool. After somewhat crude preparations, sometimes involving long steeping in household slops, liquids are obtained which can give very pleasant dyes. They are used for genuine Harris tweeds.

A grey branching lichen known as *Cladonia rangiferina*, found on moors in Great Britain and elsewhere all over the world, attains importance in the Arctic tundra for it is the chief food of the reindeer. "Iceland moss" is a lichen containing much starch; when a

bitter substance has been washed away it can be used to make bread of a kind.

The space that has been devoted to the different groups of plants has been very unequally divided among them, but most attention has been paid to those which most closely affect our lives. Thus our interest in the fern world may be restricted to the plant adorning the front window, but we are vitally concerned every day with the organisms which make our food go bad or mouldy or which may endanger our health.

TWO THOUSAND YEARS OLD

There is a tremendous range of size in plants, considerably greater than in animals. The big trees of California (*Sequoia gigantea*) have the distinction of being the largest living organisms, though it must be remembered that most of the wood is dead tissue. The tallest is over three hundred and twenty feet high with a trunk thirty-five feet thick; it is certainly two thousand years old.

These figures are as nothing compared with



ONE OF THE LARGEST FLOWERS

HAROLD BASTIN

Flower buds and bloom of Aristolochia gigas, one of the world's largest flowers. The species belongs to a genus of shrubs to be found in Europe, the United States, Central America and Mexico.



FOREST TURNED TO STONE

FOX

A petrified forest in Arizona, U.S.A. Sections of trunks lie scattered in disorder, victims it may be of volcanic eruptions æons of ages ago. Water, carrying silica and other minerals in solution, turned the trees into stone. Some of the sections weigh many tons.

the length of the family history of these trees. Fossil records show that *Sequoia* has been flourishing for something like a hundred million years; its remains have been found all over the world and, though it is now confined to a narrow belt on the Pacific coast of North America, there is no lack of vigour in this remarkable link with the remote ages before man was known.

The redwoods of California (*Sequoia semper-*



FOOD OF REINDEER

Iceland moss, a lichen which is widely distributed and the chief food of the reindeer.

virens) may be taller, though their trunks are not so thick, and the same applies to some of the Australian blue gum trees (*Eucalyptus*); they are much faster growing.

At the other end of the scale one of the smallest woody plants is the dwarf willow, a creeping alpine plant seldom more than two inches above the ground; the catkins are very small with only a few flowers.

The Japanese dwarf trees are, of course, not natural products; they are kept very small by allowing the roots little space and periodically pinching them off. Severe weather conditions have produced the dwarf oaks of Wistman's Wood on Dartmoor, with gnarled and twisted

trunks centuries old and yet only a few feet high.

Smallest of all the flowering plants is a tiny duckweed, *Wolffia arrhiza*, said to be often present in ponds with the common duckweed but overlooked on account of its minuteness. The plant is merely a floating green disc, about a twenty-fifth of an inch across, without any roots or leaves. The flower, which is rarely produced, consists of a single tiny stamen and an ovary with one seed. This may be compared with the flower of *Rafflesia*, previously noted as the largest known.

SEA-SERPENT OF SEAWEED

Another water plant, *Victoria regia*, may be mentioned for the size of its floating leaves. They are circular with an upstanding rim, and may be more than six feet across. There are very large air-spaces inside the leaf; these give it something of the feel of a modern multi-spring mattress. The leaves of this water-lily of the Amazon can support a child's weight.

One giant among the lower plants must be mentioned, a brown seaweed, *Macrocystis pyrifera*, which grows in cold waters of the Southern Hemisphere. There is a tough stem which reaches the surface of the sea; from it hang long fronds, each buoyed up with an air bladder so that most of the plant is floating. It reaches a length of over two hundred feet, and on one occasion at least has been taken for a sea-serpent.

Since the filter-passing viruses are probably non-living, we must find the smallest plants among the bacteria.

Which of all these groups and forms were the first plants like?

GOLD IN SEA WATER

There can have been no life on this planet until the earth's crust had cooled sufficiently to allow water vapour to condense on it. This may have collected at first as a world-wide sea, or there may always have been oceans and land masses with rivers and lakes. The land would have revealed bare rock surfaces, for soil is largely a product of plant and animal life, and the nearest approach to it would have been sand, into which the rocks may have been broken up.

We can hardly imagine life originating elsewhere than in water, whose presence is essential to it. At first the ocean would have been fresh water; gradually minerals would have been washed down into it from the land.



GIANT WATER-LILY OF THE AMAZONS

HAROLD BASTIN

Victoria regia in bloom. Note the immense leaf in the background, which measures six feet across, and the developing leaf to the left of the flower. Its original home was British Guiana.

Nowadays common salt is the substance present in largest amount in the sea, but it also contains nearly every known element, although some, such as gold, are only in very small quantity.

GREEN PLANTS BEFORE ANIMALS

It has been possible under special conditions in the laboratory to produce a little sugar from water and carbon dioxide when exposed to light. Perhaps this might have happened too in the primeval ocean and a store of sugars and minerals been ready for the first life. We cannot tell, but certainly there must have been green plants of a kind before animals evolved.

The simplest green plants which we know now are found among the algæ. One common pool form, *Chlamydomonas*, will serve as an example. It is a single spherical or ovoid cell with a cellulose wall. Inside is a bowl-shaped chloroplast and a central nucleus. At the colourless front end are two delicate hairs which continually lash the water and drive the cell forwards. Close to them is a tiny red spot, which possibly has something to do

with perceiving light and guiding the plant to swim to a suitably illuminated place.

When it multiplies it either divides into several smaller editions of itself or else individuals slip out of their coats, pairs of them become entangled by their lashing hairs and they mutually engulf each other in a primitive sexual process. We can see the beginnings of the separation of the two sexes, for sometimes the fusing cells are of two sizes. The larger is very sluggish, the smaller seeks it out actively and corresponds to the male.

FOOD FROM MINERAL SOURCES

Sometimes the cells lose their lashes and develop a thick mucilaginous wall. They contrive to multiply, but the cells stick together and a colony results. We can imagine it possible for this to lead to the evolution of a more complicated, many-celled plant body.

There are many of these tiny swimming forms in fresh and salt water. One of them (*Polytoma*) is colourless. It lives in water polluted with sewage, from which it obtains food. One might see in it a pointer towards

out, by elaboration of their bodies, by specialization of their functions, and by adaptation to, and improvement under, new conditions of life, the vegetation of the sea transformed itself into the green mantle of the earth. It was at first difficult to believe in the descent of the various members of the group from a common stock, so different are the life histories of the species, but there is now more or less agreement as to their close relationship in the remote past.

The seaweeds, to quote the opinion of Dr. Church, of Oxford, "illustrate in a manner beyond all other types of the plant kingdom the beginnings of plant anatomy and vegetable morphology"—the branch of biology dealing with the form of organisms.



GIANT CONIFER

A Californian big tree, a species which has the distinction of being the largest living organism.

the origin of the fungi. Many others are more like animals in their behaviour.

Tiny little plants such as these are not preserved in fossil form, and we can only guess how they might have given up swimming and settled on the bottom in shallow water, have grown to more complicated bodies, which were gradually able to invade the seashore or margins of pools and so passed to living on dry land. We can only say that fungi and bacteria appeared very early in the history of plants. Bacteria are so peculiar in their habits that it is possible that they arose quite independently from other groups of plants. Some of them, such as the iron and sulphur bacteria, obtain their food from mineral sources and are not dependent upon any other forms of life; they might have existed even before there were green plants.

As Professor J. Lloyd Williams has pointed

COMMONWEALTH OF AUSTRALIA

AUSTRALIAN GUM TREES

The tallest specimen of this magnificent tree grew in Victoria and reached a height of 470 feet.



WASTE LAND BEGINS TO BLOSSOM

KINELORSKY

A scientific worker in an experimental field in the Pamir Mountains. He is sprinkling potato plants with a fluid to protect them from insects. Not long ago the land was regarded as entirely unfit for cultivation.

PLANT BREEDING IN INFINITE VARIETY

UNTIL the nature of sex in flowering plants was understood, pollination was left to natural agencies and plant breeding was not practised. In the date palm male and female flowers are on separate plants, and as far back as the ancient Babylonians it was the custom, with religious ceremonial, to cut branches of male flowers and shake the dust over the females. It was known that this was necessary to ensure fruiting in the date, but the wonderful connection between pollination and seed production in other plants was not then appreciated.

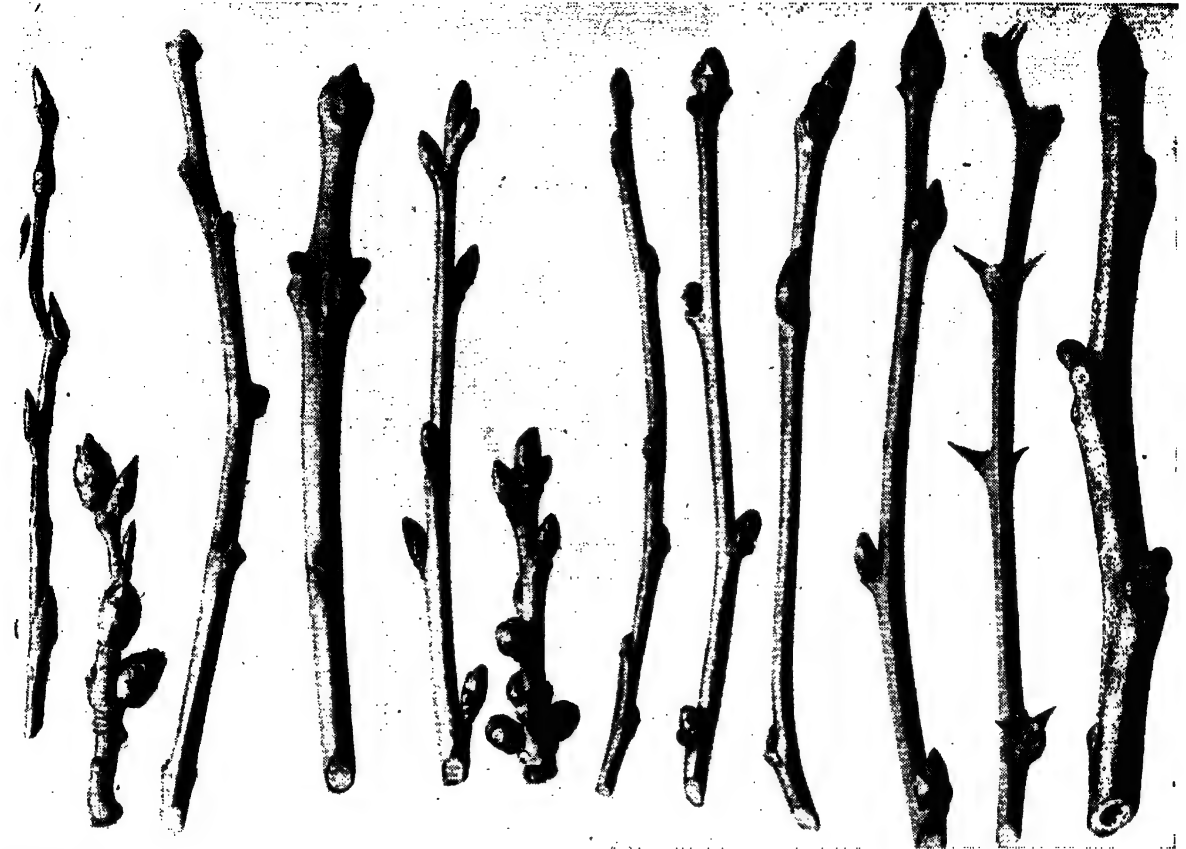
After about 1700, when sex in plants had been revealed, several kinds of plant were successfully cross-pollinated. The progeny were named hybrids, from a Latin word meaning the offspring of a cross between a domestic sow and a wild boar.

Most of our cultivated plants differ widely from the wild forms and show many variations among themselves. For example, the small

scar hard crab is the ancestor of the long list of orchard apples.

It is obvious that at some time man must have noted plants which were better than the normal types, and have deliberately selected them for cultivation. Often this is successful. Thus Vilmorin, a Frenchman, founder of the oldest existing seed establishment, set himself to make a useful plant of the sugar beet. By continuously taking for seed the plants whose roots showed the highest sugar content he more than doubled the average of this, without recourse to hybridization. Nowadays there is a whole science connected with the study of inheritance, and the specialist is able to give advice how best to tackle the problem of the production of new forms by hybridization.

The existence of heredity and variation are plain to us all. In our own families we notice that children resemble their parents in many of their characters, physical and mental, and yet none is exactly like another or either of its



HAROLD BASTIN

HOW TO IDENTIFY WINTER TWIGS

Left to right : *Aspen* (2), *wych elm*, *ash*, *wild cherry* (2), *wild apple*, *wild service*, *rowan*, *whitebeam*, *locust* and *walnut*.

parents. Certain of these differences may not be inborn or heritable. Poor nutrition may prevent a child from attaining the height of which he was capable. A parent may have lost a limb, but his children will not resemble him in his one-legged condition.

INHERITANCE IN PLANTS

Similarly a pea plant of a tall variety may be kept very short by drought or poor soil, but its seeds, given normal cultivation, will produce tall plants. Again, the offspring of a pollarded elm will not resemble it but will show the usual type of branching.

The study of inheritance is best begun by considering a few clear-cut characters in particular examples and seeing how they appear in successive generations.

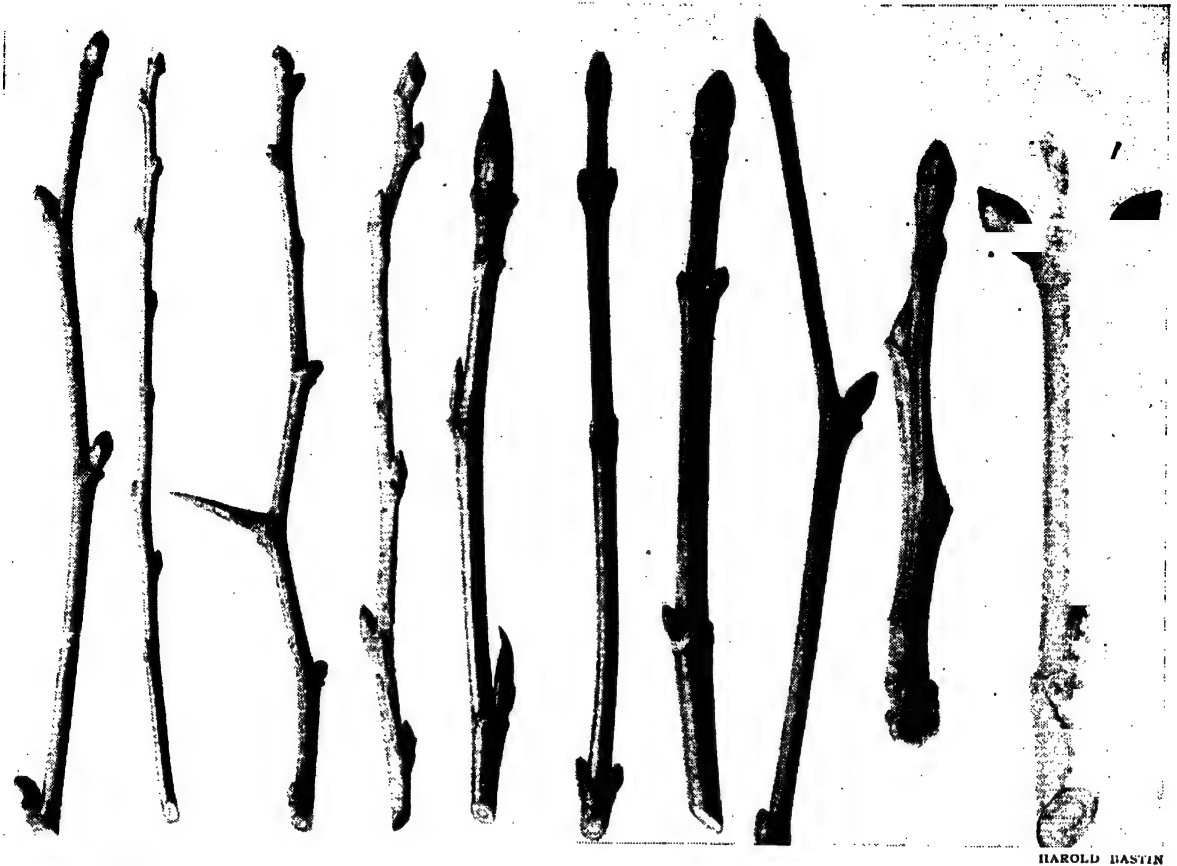
Suppose we take seed of a plant such as the bean, which is normally self-fertilized, choosing a variety which is known to come true from seed, then, no matter what are the conditions of cultivation, its characters will be handed

on unchanged from generation to generation.

In one experiment the average weight of the seeds of such bean plants was recorded; although in each generation there was a wide range the average seed weight was always the same. When in each generation only the heaviest seed was taken and grown, it might have been expected that a strain would result whose average seed weight was higher than in the original type. In reality it did not alter. Nor did it change when instead the lightest seed from each generation was taken. The size the seed attains depends upon conditions around it when it is growing; these do not affect its hereditary constitution.

UNCHANGED BY OUTWARD CONDITIONS

The conclusion is that in true breeding strains, when there is no crossing, the heritage is unchanged by outward conditions throughout many generations. It is a different matter when two different strains are crossed; there



HAROLD BASTIN

--THAT GROW IN GREAT BRITAIN

Left to right : Hazel, blackthorn, hawthorn, white poplar, black poplar, maple, sycamore, plane, sweet chestnut and horse chestnut.

is much more to be learnt from the results of this operation.

The problem was first studied systematically by Gregor Mendel, an Austrian monk, whose conclusions were published in 1865. They are now recognized as having made a revolutionary step forward in biology, but at the time they were ignored. It was not until 1900, years after Mendel's death, that attention was redirected to his work and his name made famous.

DIFFERENT TYPES OF OFFSPRING

Mendel worked with garden peas, of which there are a number of well-marked varieties, such as tall and dwarf, yellow- and green-seeded, purple- and white-flowered. Having proved that his plants came true from seed, he studied the results of crossing forms with these clearly contrasted pairs of alternative characters and followed them through several generations. This was not a new line of work but Mendel was the first to make accurate

counts of the numbers of the different types of offspring and to draw conclusions of general application from his results.

MASTERING AND DISAPPEARING FACTORS

When tall and dwarf strains were crossed the resultant seeds all produced tall plants. They were not intermediate in height, and there was no suggestion that anything which could govern dwarfness had been passed on from the other parent. But if the hybrid plants were allowed to set seed by self-pollination (the normal method in the pea), dwarfness reappeared in roughly a quarter of the offspring, the rest being tall. There must therefore have been concealed in the hybrids some factor which could make plants dwarf, otherwise they would not have been able to pass it on to some of their descendants. It can only have been derived from the dwarf parent of the hybrids.

Mendel described the factor which made for tallness in peas as being dominant (or mastering)

in a number of these pairs of alternative characters. The hybrids will be of a uniform type, only showing those of the pairs which are dominant, but on selfing them (i.e., letting them set seed with their own pollen) there will appear all possible combinations of the characters. When several are being considered this means that a great variety of new forms will be produced. Some will breed true, and from others pure breeding strains may be isolated by continually selfing them. This is the procedure often adopted, but it must not be supposed that the work is always straightforward or that the inheritance of all characters is clearly understood.

INCREASING THE ACREAGE OF WHEAT

Very soon after Mendel's principles had become widely known and had been confirmed it was found that they applied also to the inheritance of less easily-defined characters, such as resistance or susceptibility to disease, and early or late flowering. Planned efforts were made with wheat to combine desired features of this type with good yield. An important product was "Marquis," which was bred in Canada from a cross between "Red Fife" and a very early maturing Indian wheat known as "Hard Red Calcutta." "Marquis" is about a week earlier in ripening than "Red Fife," and so could be grown considerably farther north. It greatly increased the acreage of wheat in Canada. From "Marquis" still earlier maturing forms such as "Ruby" have been developed and cultivation spread still nearer the North Pole.

RESISTANCE TO RUST

Unfortunately "Marquis" is susceptible to the attack of the destructive rust fungus. In 1930 the bread wheat and another species which was resistant to rust were crossed; only one plant with shrivelled seeds resulted, but some grew and after a few generations a strain named "Hope" was produced which possesses a wonderful resistance to all types of rust disease and also has many desirable characteristics. It is solving the problems of many American growers.

In the same way the two varieties "Spratt-Archer" and "Plumage-Archer," which account for three-quarters of the barley grown in Britain, were bred so as to combine by hybridization of suitable forms the qualities most desired by farmers and brewers.

Natural hybrids sometimes occur and some have proved of importance. The cord-grass (*Spartina Townsendii*), which covers so much of the tidal mud in Southampton Water, appeared there in 1870. It was an entirely new plant and probably arose by the crossing of an insignificant native grass with a related species accidentally introduced from America. It was amazingly successful and has spread over



HAROLD BASTIN

PRODUCES HAIRY FRUIT

If the hairy peach and the smooth-skinned nectarine are crossed, the hybrid plants bear hairy fruits.

hundreds of acres of sea flats. Its untidy looking tussocks of stiff leaves bind the mud and gradually raise its level so that the land may be reclaimed. During the World War some use was made of its fibres for paper, and it is not without value as herbage.

For years unsuccessful efforts were made to cross a blue delphinium with the red-flowered *Delphinium nudicaule*, sometimes seen in rock-gardens. One year, among the rows of the two kinds, a purple-flowered plant appeared. It proved to be a natural hybrid between them and from it many new shades have been derived. In 1937 the form "Pink Sensation"

origin of species was that all members of a species showed slight variations. Some of these might be advantageous to the form possessing them and would favour its preservation in the struggle for existence. So he thought the variations best fitted to the conditions around them would survive and new species be gradually evolved by a continuation of this process. Nowadays it seems much more likely that new forms are produced by relatively large changes, the cause of which is generally unknown.

JUMPS IN EVOLUTION

When the sweet pea was first brought to England from Sicily in 1699 it had small, purple, scented flowers. It is normally self-pollinated but in the course of years several new types appeared, such as white, red and picotée flowers. Hybridization was not practised until 1880. Suddenly, in 1900, a most important advance occurred when the Spencer form with waved standards appeared in four different places among plants of the variety "Prima Donna." The Spencer type has now quite ousted the old-fashioned varieties, but many of the modern sweet peas lack the delicious fragrance of less showy types.

Such sudden sports or jumps in the evolution



DOMINION OF CANADA

COMBINING DESIRED FEATURES

Red Fife wheat (left) introduced into Canada from Danzig; Ruby, a cross between Downy Riga and Red Fife.

was first shown in London. Some, who feel that blueness is the character for which the delphinium is most to be prized, will think that it is as little to be desired as a blue rose.

HOME OF THE PLUMS

Scientists have suggested that the cultivated plum may have arisen in the wild by the crossing of the red-skinned yellow-fleshed cherry plum with the sloe, which has a blue skin and green flesh. Russian botanists have recently found in the Northern Caucasus, which they think to be the home of the plums, that the sloe and cherry plum grow there and also a wealth of forms which they think are natural hybrids between the two.

It is well known that new varieties sometimes appear suddenly. Darwin's theory of the



DOMINION OF CANADA

INCREASING THE YIELD

Hard Red Calcutta wheat (left) and Marquis. The latter is bred from a cross between the former and Red Fife.

of new forms are common in horticulture. The dainty, free-flowering belladonna type of delphinium is of unknown origin but has been grown for years; it set no seed and was increased by cuttings or root division. In 1902 three seed-pods appeared on one plant and from them a whole race of belladonna hybrids have been raised, all setting seed normally.

PLANTS THAT CANNOT SEED

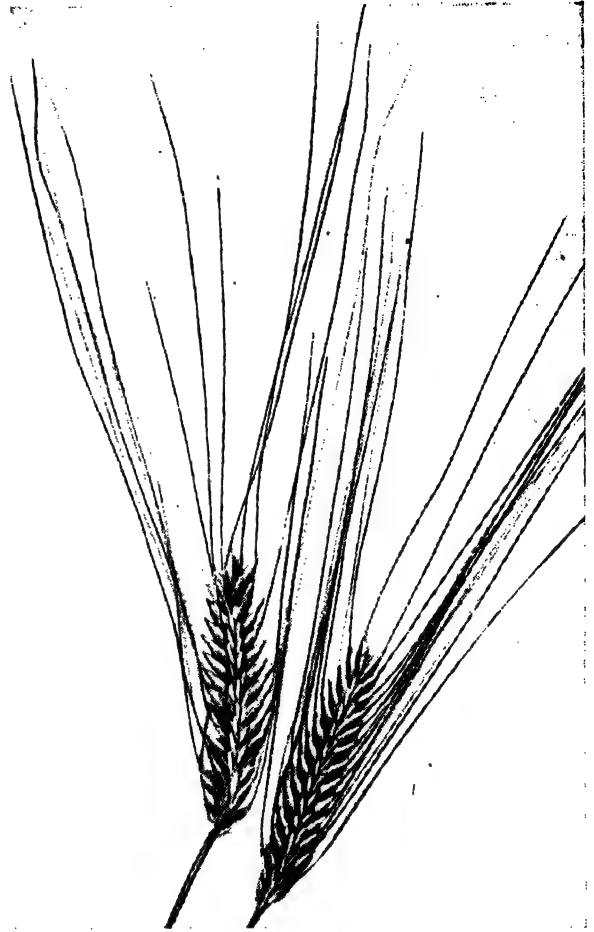
Many of our horticultural forms might have been produced in nature but they would never survive in competition with the original types. It is the practice of many breeders to spoil (or so some think) the purity of floral form by producing double varieties. Often the extra petals are transformed stamens and the plants cannot set seed. Many of our best apples, such as "Bramley's Seedling" and the crimson form which arose as a branch sport from it,



SPRATT-ARCHER BARLEY

Spratt-Archer (left) and Plumage-Archer (right) account for three-quarters of the barley grown in Britain.

HAROLD BASTIN



HAROLD BASTIN

PLUMAGE-ARCHER BARLEY

Bred with Spratt-Archer to combine by hybridization qualities desired by farmers and brewers.

are almost completely sterile and are only kept going by artificial budding and grafting.

PLANTED UPSIDE-DOWN

Curious results sometimes follow when plants of two species are united. Apples are normally grafted on stocks of a different type, sometimes pear or quince, but this does not radically change their nature. In 1825 a Frenchman grafted the small broom *Cytisus purpureus* on the common laburnum. From the union a bud developed which produced leaves and flowers intermediate between the two. This form is still kept in existence by vegetative reproduction. Occasionally shoots with the leaves and drooping clusters of yellow flowers of the laburnum appear, and there may be on the same plant others with the small leaves, stiff habit and scattered purple flowers of the broom. The so-called "graft-hybrid" seems

to consist of a core of laburnum tissue surrounded by a skin of purple broom; every now and then the two separate.

Similar peculiar forms have been produced by grafting together the hawthorn and medlar. The variegated *Pelargonium* (the geranium of gardeners) with white-margined leaves is of a comparable nature, though its origin is unknown. There is a green core, surrounded

flowers are salmon coloured with fringed petals. But often a branch shoots out with flat hairy leaves and normal flowers; this is supposed to constitute the core of the plant. Country people assent that if a primrose is planted upside-down the flowers will be pink. No one ever seems to test the truth of this statement, but it is certain that some geraniums, when treated like this, produce shoots (from root buds) of a very unexpected type.

BURNING FORTY THOUSAND PLANTS

One of the most famous plant breeders was the American Luther Burbank (1849–1926). Even in his cradle he showed his love for flowers. After great privations, when he was even reduced to sleeping in a chicken coop, he started a nursery garden in California. His first big order was for twenty thousand young prune trees to be delivered in nine months' time. Normally it would take at least two and a half years to rear the plants. With characteristic originality and resourcefulness Burbank sowed the quick-growing almond; soon the saplings were big enough for prune buds to be grafted on them and the order was successfully executed.

After a time he closed his business in order to devote himself to plant breeding, finally receiving government support. His experiments were conducted on a vast scale. As many as five hundred thousand lilies were grown in one test; their fragrance spread a mile away. In another, forty thousand black-berry-raspberry hybrids were grown to maturity. One single plant was chosen as the best, and the rest burnt in a pile twelve feet wide, fourteen feet high and twenty feet long.

Money meant little to him. The Burbank potato, which increased the wealth of the U.S.A. by millions of dollars, he sold to a nurseryman for a hundred and fifty dollars (£30). His plums and prunes were of great value in California. After years of work he produced a luscious plum without a trace of a stone. The "plumcot" was a union of plum and apricot.

TO MAKE THE DESERT FERTILE

The Shasta daisy, with blooms up to seven inches across, was derived from small-flowered wild varieties. One day he noticed a yellow Californian poppy (*Eschscholtzia*) with a tiny streak of red in the petals. This was seized and from it a pure red form developed. The



HAROLD BASTIN

ENEMY OF THE FARMER

The destructive rust fungus on barley. On the left is an ear before being attacked by the disease.

by a white skin. That the interior of the plant is really different from the skin is proved by taking root cuttings. On these the buds arise deep in the tissues; they produce pure green shoots. The pollen grains and embryo seeds develop from the outer white skin layers and so, when such a *Pelargonium* is selfed, the seedlings which result are pure white. As they have no chlorophyll they cannot manufacture food for themselves and they soon die.

The pelargonium "Salmon Fringed" is a similar union of two types. Normally the leaves are funnel-shaped and smooth, and the

origin of the famous Shirley poppies was somewhat similar; an English clergyman found a wild red poppy with a thin white margin to the petals and from its seeds and their offspring the many colours we know today arose.

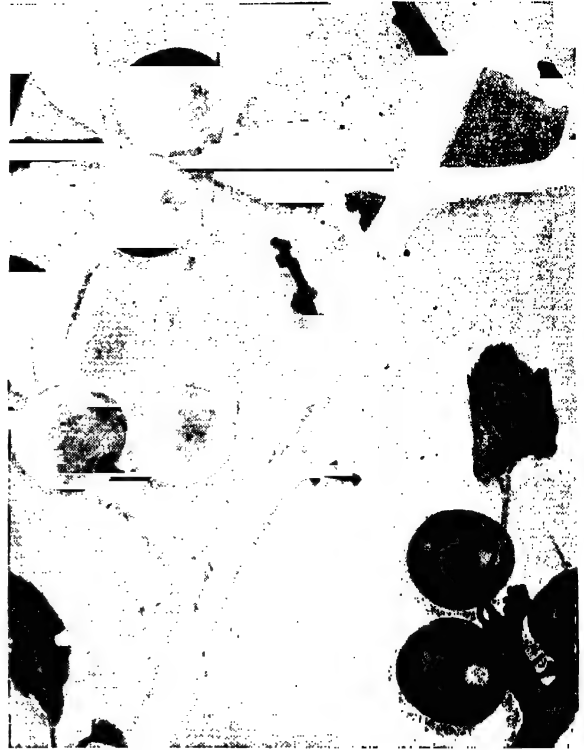
As a little child Burbank would toddle round with a potted cactus as his dearest toy; in his maturity one of his greatest triumphs was the production of the edible thornless giant cactus. With this he hoped to make the desert fertile.

WALNUTS WITH THIN SHELLS

His "Paradox" walnut is well known in the United States. He crossed an English and a Californian walnut, and finally raised trees which in fourteen years grew six times as much as the Californian parent had in thirty years. The wood is close and fine-grained and is a valuable timber. To the nuts he paid little attention. One day he thought that a thinner shell would be an improvement, so he continually selected saplings pointing in this direction until the shells were so thin that birds pecked through them!

Burbank was no trained scientist. His method was to cross chosen forms and grow all the resultant seeds. Their progeny in turn would give him a large collection, from which he selected only those approaching the desired forms. Further large families would be grown from them.

He was scornful of the scientific principles of plant breeding and considered that his



HAROLD BASTIN

SLOES

A wealth of forms probably hybrids between the sloe and cherry plum are found in the Northern Caucasus.

results completely disproved them. In this he was wrong. Mendel's laws teach that when two different forms are crossed the various hereditary characters will be recombined in all possible ways in the second generation after the cross; this is exactly what he found: he worked with forms differing in a number of characters and the very large families he raised would emphasize the variety of new types arising. From one cross he had two thousand poppy plants, among which the leaves of no two plants were alike in form. He would continually discard all but the most hopeful plant and try by breeding from that to obtain a pure strain. Intuition played a greater part than science in picking out the right plants, but the results justified it.

PESTS OF THE VINE

Of late years breeding experiments on a scale even larger than those of Burbank have been carried out. The German vine industry is said to have been devastated by two pests, mildew and the vine-louse. A North American vine is resistant to their attacks, but its grapes are poor, so the European variety was crossed with it. By 1933 it was said that as many as



HAROLD BASTIN

PARENT OF THE PLUM

The crossing of the cherry plum (above) with the sloe probably gave the cultivated plum to the world.



BROOM IN FLOWER

HAROLD BASTIN

The union of broom and laburnum produces leaves and flowers intermediate between the two.

ten million hybrid seedlings had been raised. These are all artificially infected with the mildew; any that resist it are handed over to the vine-louse. It was hoped that in ten years the problem would be solved.

EXPERIMENTS IN RUSSIA

The botanists of the Soviet Union are carrying out hybridization experiments on a magnificent scale, embracing all the plants commonly cultivated over their wide climatic range. The guiding principle has been to collect first all their known varieties, so that the different characters possible in each plant will be at hand for breeding experiments. Thus over five thousand different wheats are sown annually and the scientist will find amongst them the characters he desires to combine, if they exist at all in the wheat.

Plants have been gathered from all over the world and the places of origin of many cultivated plants found. These usually prove to be a few mountainous regions, where conditions are often severe. There is some evidence that the sudden sports which often produce

new forms are more likely to occur in such circumstances.

In these regions are a great variety of forms and it seems that often the cultivated plants have been derived from only a few of them; there still exists in the wild a wealth of plants with valuable characters, which when combined with others by hybridization may solve many problems. Thus one wild wheat shows great resistance to mildew, smut and rust and to insect attack. This only needs to be combined with the good yield and baking qualities of cultivated wheats.

EDIBLE FRUITED HONEYSUCKLE

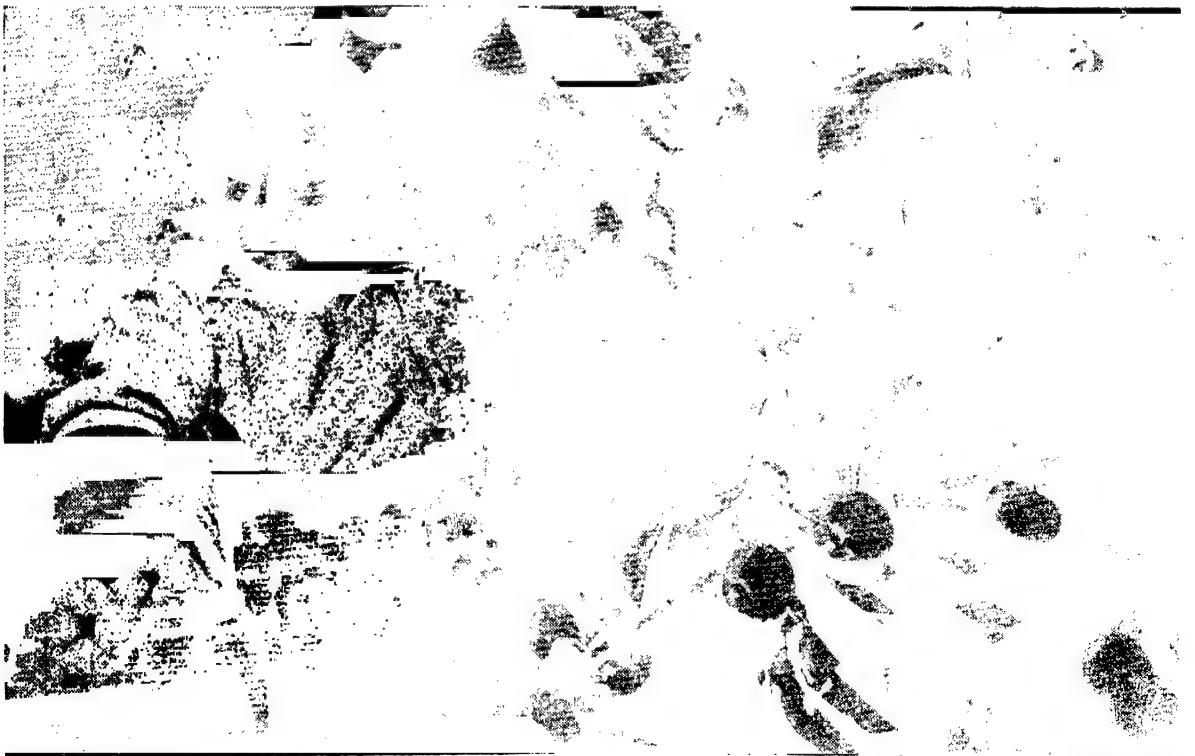
In the mountains of Central Asia and the Caucasus the Russians found a great variety of apples, plums, cherries, vines and other fruits. Many are very hardy and have been used to produce new types capable of fruiting much farther north than before, in lands that previously were barren. Frost resistant vines and apricots and edible fruited honeysuckle and mountain ash are some of the new forms produced from them.

Much attention is being paid to the potato. It has been cultivated in South America for centuries, but was unknown in Europe until



PRODUCER OF THE PLUMCOT

Luther Burbank, who did wonderful work in plant breeding and gave many new varieties to the world.



MAKING THE POTATO FLOURISH IN THE ARCTIC

PLANET NEWS

A research worker in the Arctic Murmansk region crossing potato flowers to cultivate a potato suited to the climate. Below: Gathering fruit in Alma-ata, Kazakhstan. Alma-ata is known as the "Father of Apples."

1587, when a tuber reached Vienna, and the next year England. They were evidently of hybrid origin for the seeds obtained from the plants produced a number of varieties and the strange vegetable gradually won favour.

ROMANCE OF THE POTATO

There is no certainty as to who introduced the tuber into England; even the date is disputed. Both Sir Francis Drake and Sir John Hawkins have had the honour thrust on them, and it has also been stated that returned colonists from Virginia took it to Ireland and not Sir Walter Raleigh. There is a tradition that the first crop was grown at Brixton, near London, and another that it was raised in Lord Burleigh's garden in the Strand. Certainly it was at first regarded with grave suspicion, and alarmist reports were spread that it caused leprosy and other dire diseases.

Some ten years following its arrival, the potato is described in Gerarde's *Herbal*, where it is stated that some of the roots "are as a ball, some oval or egg-fashion, some larger, some shorter, the which knobby roots are fastened into the stalks with an infinite number of thready strings. It groweth naturally in America, where it was first discovered, as report says, by Columbus, since which time I

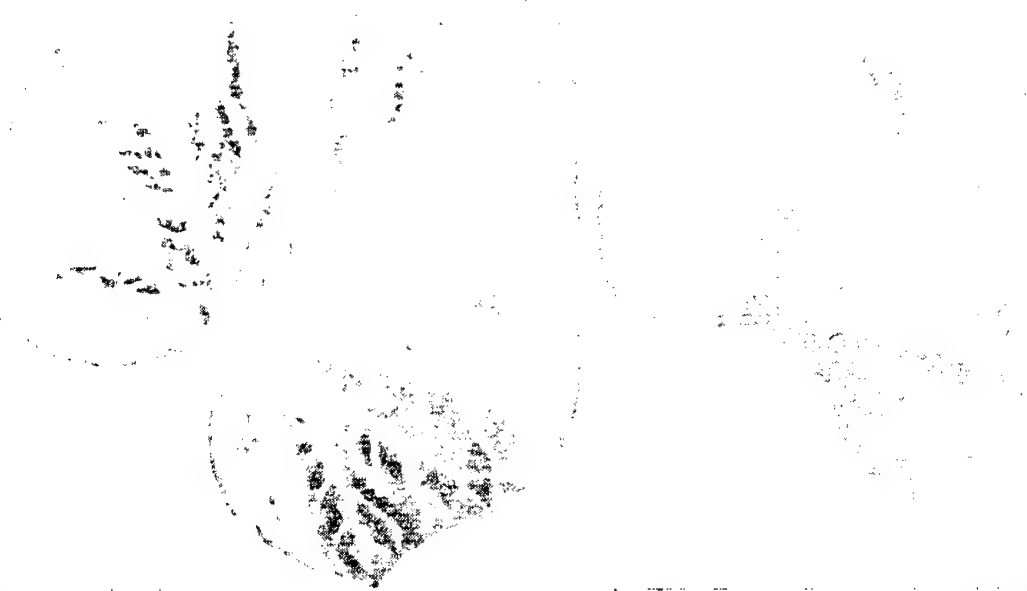
have received roots hereof from Virginia, otherwise called Nurenbega, which grow and prosper in my garden as in their own country."

Dr. Parmentier was ridiculed when he praised them in France, but he managed to interest Louis XVI. At a ball Queen Marie Antoinette wore a wreath of potato flowers and the king granted Parmentier a plot on which to grow them. A guard was provided for it and the people then thought there must be something valuable there; at night they stole the plants, cooked and ate the tubers and found them good.

Ireland came to make it the staple food and with its aid the population increased from two millions in 1785 to over eight in 1845. In that year the potato blight, a fungous disease, struck the crop. The nature of the attack was quite unknown and nothing could be done to stop its ravages. Several hundreds of thousands actually died of starvation and all who could emigrated to America.

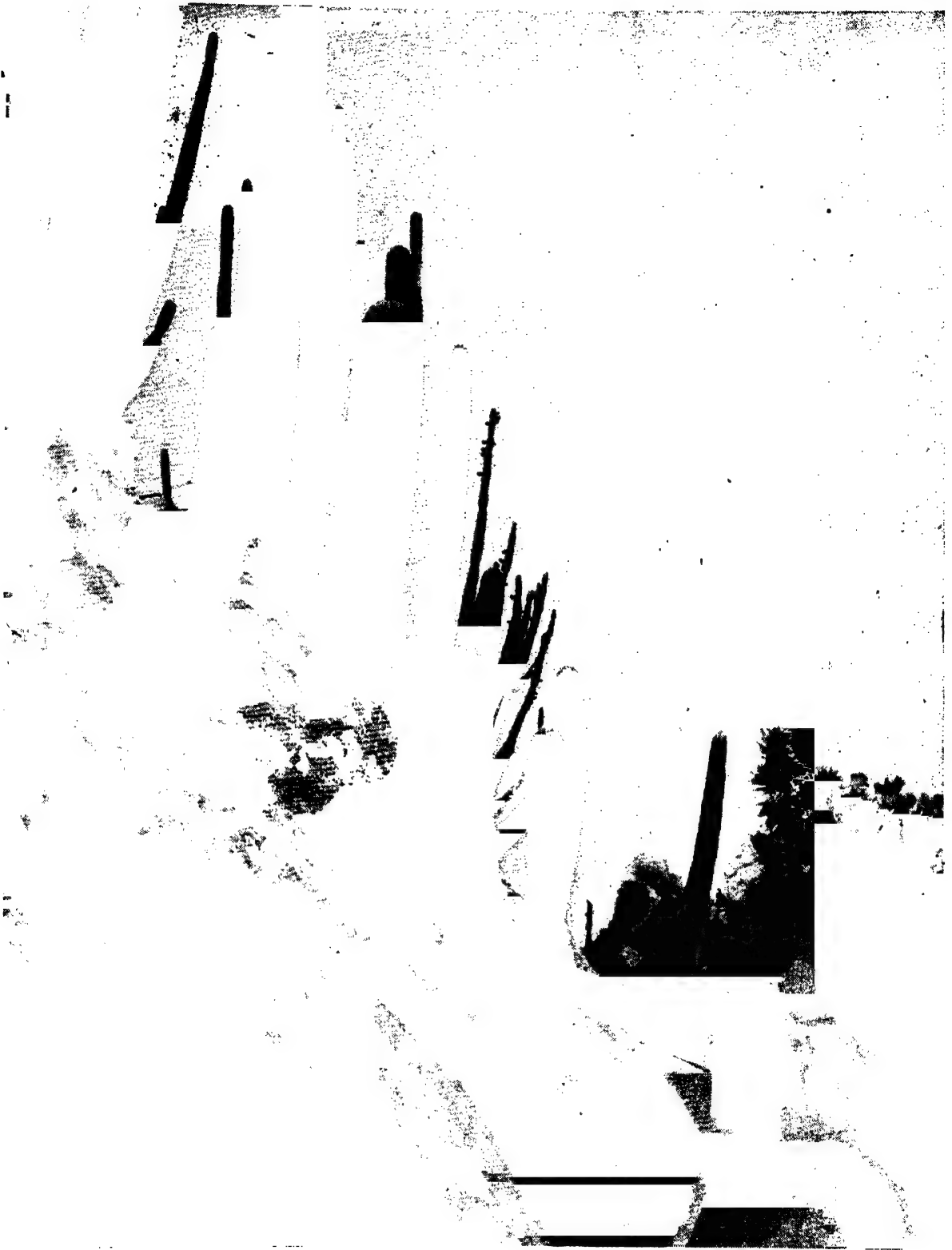
EIGHT THOUSAND VARIETIES

Grieved by their sufferings, a New York clergyman, the Rev. Chauncey Goodrich, set himself to study the problem of the potato. He thought (though wrongly) that the disease arose because the constitution of the plants



ELECTRICITY IN THE SERVICE OF AGRICULTURE

On the left is a cucumber leaf grown in a glasshouse with the help of electric light and heat, and next to it a leaf of the same kind of plant grown under ordinary conditions.



MOST WONDERFUL CACTI IN EUROPE

The exotic gardens at Monaco have the most wonderful collection of cacti in Europe. Some of them grow to a height of fifteen feet. Luther Burbank produced an edible thornless giant cactus.



RISCHGITZ COLLECTION

CHAMPION OF THE POTATO

Antoine Parmentier (1737–1813), whose writings did much to dispel prejudice against the potato in France.

had been weakened by the continued vegetative reproduction, and decided to grow them from seed. However, many potatoes rarely flower and set seed, so he obtained some plants from South America, which he hoped would "bring in fresh blood." Among them one with a rough purple-skinned tuber was the most hopeful, and with its aid he reared eight thousand different varieties.

GROWN IN EVERY CONTINENT

It was said of Goodrich that he was "so busy with experiments he had no time to make money." From his potatoes the famous "Early Rose" was derived. Burbank's potato was probably a sport from it, and it was used by English breeders.

By the beginning of the twentieth century the characters of the original varieties and of Goodrich's new strain had been combined in so many ways that the limit had nearly been reached, with many problems unsolved. The potato under cultivation is liable to attack by perhaps a greater number of fungous and virus diseases than any other plant, and resistant forms, with other characters that satisfy the requirements of growers, marketers and consumers are needed. Thus in Great Britain the shape and texture of the potato preferred

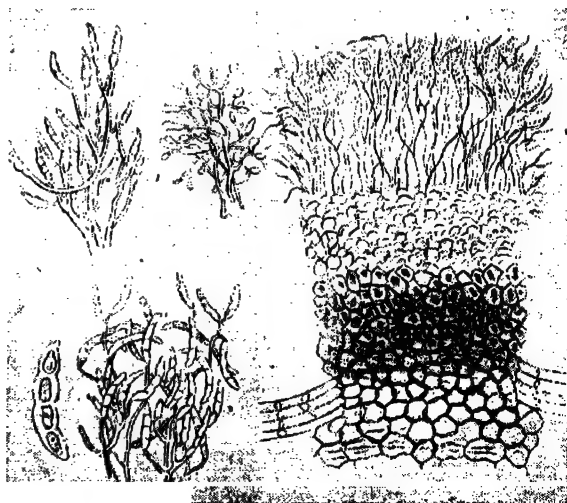
by fish-friers is an important consideration; suitable varieties are often very susceptible to disease.

The soil which has been found particularly favourable to the growth of the potato in Great Britain is that left by the draining of the fens and the rich alluvial material reclaimed from the sea. For a similar reason the polders of Holland, also recovered from the North Sea or the Zuider Zee, furnish a valuable crop. The plant is cultivated under varying climatic conditions in every continent. Even in the region of the Andes, between nine thousand eight hundred feet and thirteen thousand feet above the level of the sea, crops are grown.

LARGEST FOOD CROP

The Russians in 1925 sent expeditions to South America to see what the potato was really like in its natural home. They found an astonishing range of wild and cultivated forms, some growing in tropical conditions, others near the snow-line (the English potato cannot stand frost); some forms are resistant to fungal attack, others to drought. With this wealth of new types it should be possible to make great advances in the production of good varieties for cultivation. One hopes that these may become generally available, for the potato is perhaps the largest of the world's food crops.

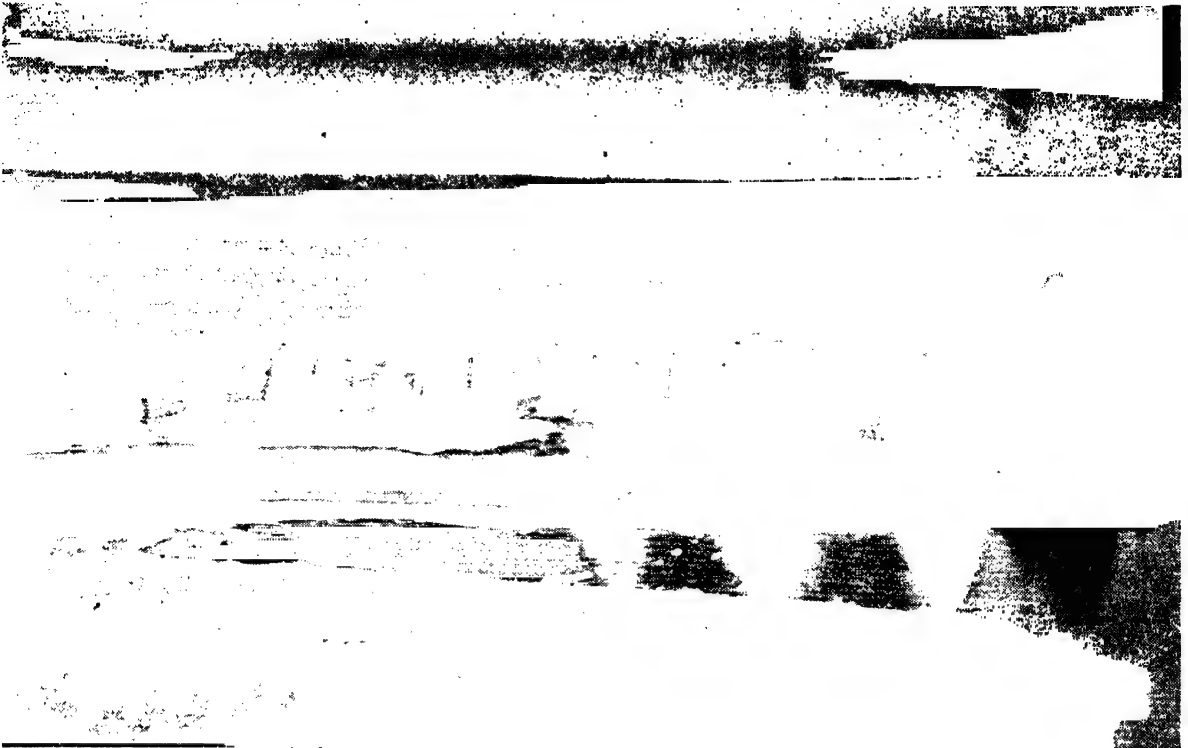
It is to be regretted that there is so little provision in Great Britain for work such as this, on the grand scale which is necessary if results are to be gained at all quickly.



HAMILTON COLLECTION

POTATO BLIGHT

A fungus disease which resulted in hundreds of thousands of deaths from starvation in Ireland in 1845.



HAROLD BASTIN

FIRST STAGE IN THE MAKING OF COAL

Stacks of peat, which is decayed vegetation. It is invariably found in bogs, marshes and swamps. The decaying matter below is constantly added to by successive generations of plants until it becomes a form of coal.

PLANTS AND MAN

THE aim throughout this whole section on plants has been to deal with them as far as possible in their relation to man. It has been shown that we depend finally upon plants for our food. Much, of course, comes directly from them, and it is possible to live entirely on a vegetarian diet.

Cereals bulk largest in our meals. It was a great step forward when wandering tribes first began to cultivate them and collect their seeds for food. This meant that they had to settle down for the best part of a year in order to produce the crops; civilized arts had time to develop and homes were made.

It is thought that wheat was first cultivated in Central Asia, which is regarded by many authorities as the cradle of civilization. It is a region specially favoured, for it seems to have been the natural home of a great many valuable crop plants. Wheat has always been the food of the world's aristocrats. More millions depend upon rice than on any other cereal, while maize, barley, rye and oats feed others.

It is only within the last few centuries that cane and beet sugar have been available. Previously to that honey was the only sweetening agent known. It is questionable whether the large amounts of sugar we now eat are particularly good for us.

There are many valuable oils obtained from seed and fruits of plants such as the olive, the pea-nut and above all the coco-nut palm, which provides most of the fat for margarine and soaps.

Nowadays pepper is the only important spice, but in the Middle Ages such flavourings as cinnamon, nutmeg and cloves were of fabulous value; a pound of the latter would buy seven sheep, and rents were sometimes paid in peppercorns. In their recipes spices are used so lavishly that the meats could not have been tasted. Probably the disguise was necessary, for there were no means of keeping it fresh, and in winter only salted meat was available.

Among other essentials which we obtain

from plants is coal, the fossilized remains of forests of distant ages. From trees too come our furniture and much of the structure of our houses. Wood pulp provides most of our paper and also the modern fabric "rayon." Silkworms feed on mulberry leaves and the transformed plant matter reappears from their spinnerets as threads of silk. Manufacturers imitate this by preparing a cellulose compound from wood pulp and forcing it through minute holes into a hardening liquid. Threads of rayon result.

TREE OF THE GODS

Flax fibres and cotton seed-hairs provide other material for weaving. These fabrics used to be dyed with plant products, such as madder and indigo, but the chemist now manufactures from coal-tar derivatives vastly superior and fast colours. But these can still be traced back to plants through the coal.

We rely on plants for nearly all our drinks. Our appreciation of them is largely due to the presence in them of drugs, among which alcohol must be included. Tea and coffee both contain caffeine, which stimulates the nervous system, and there is a similar substance in cocoa, which Linnæus termed "the tree of the gods."

Many of the medicinal drugs, such as strychnine, digitalis and cascara, are of plant origin. Their use dates back centuries to when, by a painful process of trial and error, men learnt the properties of various plants. Valuable though they are, few drugs will in themselves cure disease, and faith is still one of the most important ingredients of the bottle of medicine. Quinine is an exception, for it actually destroys in the blood the parasites which cause malaria.

Its ravages were widespread, and to its weakening effect the fall of the Roman Empire has been attributed. In 1638 the Countess of Chinchon lay dying of malaria in her Peruvian palace. To her was sent a packet of a reddish bark with orders to the physician to administer it in powder form. The cure was miraculous, and the Countess took back to Spain the marvellous bark, whose uses the South American Indians had discovered. Its fame spread over the world.

SMUGGLED FROM PERU

The demand for quinine was great, but the Peruvians were lazy, and made no effort to cultivate the forests of cinchona trees. There was a danger of world shortage, yet it was



ONE OF THE ALLIES OF CIVILIZATION

HAROLD BASTIN

A bundle of esparto grass and three flowering heads. Esparto is used in the making of some of the better kinds of paper. Wood-pulp is more generally employed in the production of newspapers.



TREE OF DESTINY IN ANCIENT ATHENS

Scarcely two months after the tree has pushed its head above the soil it is ready to bloom. Sometimes reaching a height of eighteen feet, it grows vivid red blossoms and then dies.

with the greatest difficulty and hazard that seeds and seedlings were smuggled from Peru to India and Java. It is upon the labours of the Dutch in that island that we now depend.

Few plants have had more influence on mankind than the opium poppy. From the milky juice of its seed-heads is extracted morphia, which gives welcome relief from pain. But, in the East especially, over-indulgence in the drug has wrought havoc with millions.

Countless uses are found for another milky juice, that of the rubber trees. Columbus recorded his amazement when he saw Indians playing with balls which were elastic and

bounced, but rubber was of little practical value until it was discovered that by mixing it with sulphur it was greatly strengthened and made more elastic. During the World War German chemists were able to manufacture a rubber substitute that closely approached the natural product.

Americans would not care to be without the juice of the sapodilla plum, from which they make chewing-gum. Of plant resins, gums, scented oils, of camphor, cork and many other products there is not space to tell. Suffice it to say that so varied are plant products that it is possible for the inhabitants of the tropics to supply nearly all their wants from one plant, the coco-nut palm.



COCOA AND CHOCOLATE IN THE RAW

The home of the cocoa tree is South America, but here natives are drying the beans or seeds on the Gold Coast. The trees grow to a height of thirty feet, and usually bear fruit for about twelve years. Each pod contains about forty beans.



EWING GALLOWAY, N.Y.

INVOKING THE GOD OF THE RAIN

Natives of Zululand invoking with solemn jervour and outstretched hands the god of the rain to send a plentiful supply of "cloud water" so that the land may be fertile and yield her increase to the tribe.

MAN'S FAMILY TREE

ALL the living races of mankind as they exist in the world of today belong to one species, *Homo sapiens* (from Latin *Homo*—man and *sapiens*—wise, possessing intelligence). This name expresses the fact that man is distinguished from other members of the animal kingdom, and more especially from the members of his own order and family—which include monkeys and the great apes—by the possession and habitual exercise of the specific quality of being able to reason.

In the days before Darwin wrote *T^{he} Origin of Species* (published in 1859), it was believed that all species in the world of nature, each in its respective kind, were fixed and as God had made them in the beginning. But when once the doctrine of evolution was formulated and applied to the origin and development of the various forms of life, it was natural and inevitable that further questions should be asked. Had man always been what he is now? If not, what was he like before he became modern man as we know him? And if he had evolved

from an earlier and more primitive form, had he any near relations who could be shown to have a like ancestry?

Of these problems the last in particular raises an obvious issue. It is evident at even a casual glance that monkeys and the great apes bear a close resemblance to man, both in form and to a certain extent in behaviour. It is owing to this similarity of form that zoologists have classified man and the great apes—gorilla, chimpanzee, orang-utan—and the gibbon, the diminutive member of the group, in one family as being closely related.

So striking is this resemblance that it was believed by many in the early days of evolutionary theory that monkeys represented an ancestral form of man, and that man's family tree could be traced back to one or other of the great apes, preferably the gorilla or the chimpanzee. More carefully detailed comparison of the skeletons, brains, muscular and nervous systems of man and the great apes showed that such a line of descent was not possible.

It was found that instead of man's anatomical characters showing a greater likeness to any one member of the group, to the exclusion of all the others, as would be expected if he were descended from that form, the resemblances were distributed fairly evenly over all members of the group. In certain characters man was more like the gorilla than any other ape, in other characters more like the chimpanzee, and so on, the balance, if any, being rather in favour of the little gibbon, with the chimpanzee, perhaps, as second.

MAN'S PAINFUL PROGRESS

The conclusion to be drawn was not that man was descended from any one of the great apes as we know them, but that at some remote period in the history of the world, the monkeys, the great apes and man had had a common ancestor, from whom all members of the family were descended, and whose characters had been inherited in varying degree and with widely differing modifications and adaptations by each of the different members of the group. The apes were shown to be neither primitive nor rudimentary forms of man. Each in its kind, equally with man, is a highly developed type.

The superficial characters in which the apes and monkeys resemble man are too well known to need enumeration, while the resemblances in structure on which the comparative anatomists rely chiefly are of a highly technical nature. One distinguishing character of man, readily to be appreciated and most significant for the present purpose, is his ability to walk upright.

As we look back over the early phases of man's slow and painful progress towards a higher form of existence, three factors stand out as crucial in the stages of that advance. Of these the most important is the assumption of the upright posture. When man began habitually to stand and walk erect, as opposed to the occasional assumption of this position by the apes, it entailed an alteration in the position of the internal organs and the character of their muscular supports in the human abdomen. This changed the balance of the body and the carriage of the head on the vertebral column or backbone, while releasing the fore-paws and fore-limbs to acquire those functions of arm and hand which have played a predominant part in the development of the specifically human activities for which they are a necessity.

The upright mode of progression also conferred upon man the advantage in the struggle

for existence of a greatly extended flexibility and range in vision and movement, and more especially a freedom in the employment of head, trunk and fore-limb. These advantages made it possible for him to use, adapt and fashion material aids for attack, defence or protection to counterbalance his weakness, as compared with other members of the animal kingdom, in natural means of defence against his enemies or the rigours of climatic conditions. They made up for his deficiency in tooth and claw as a fighter and the loss of his coat of fur which once had kept out the cold.

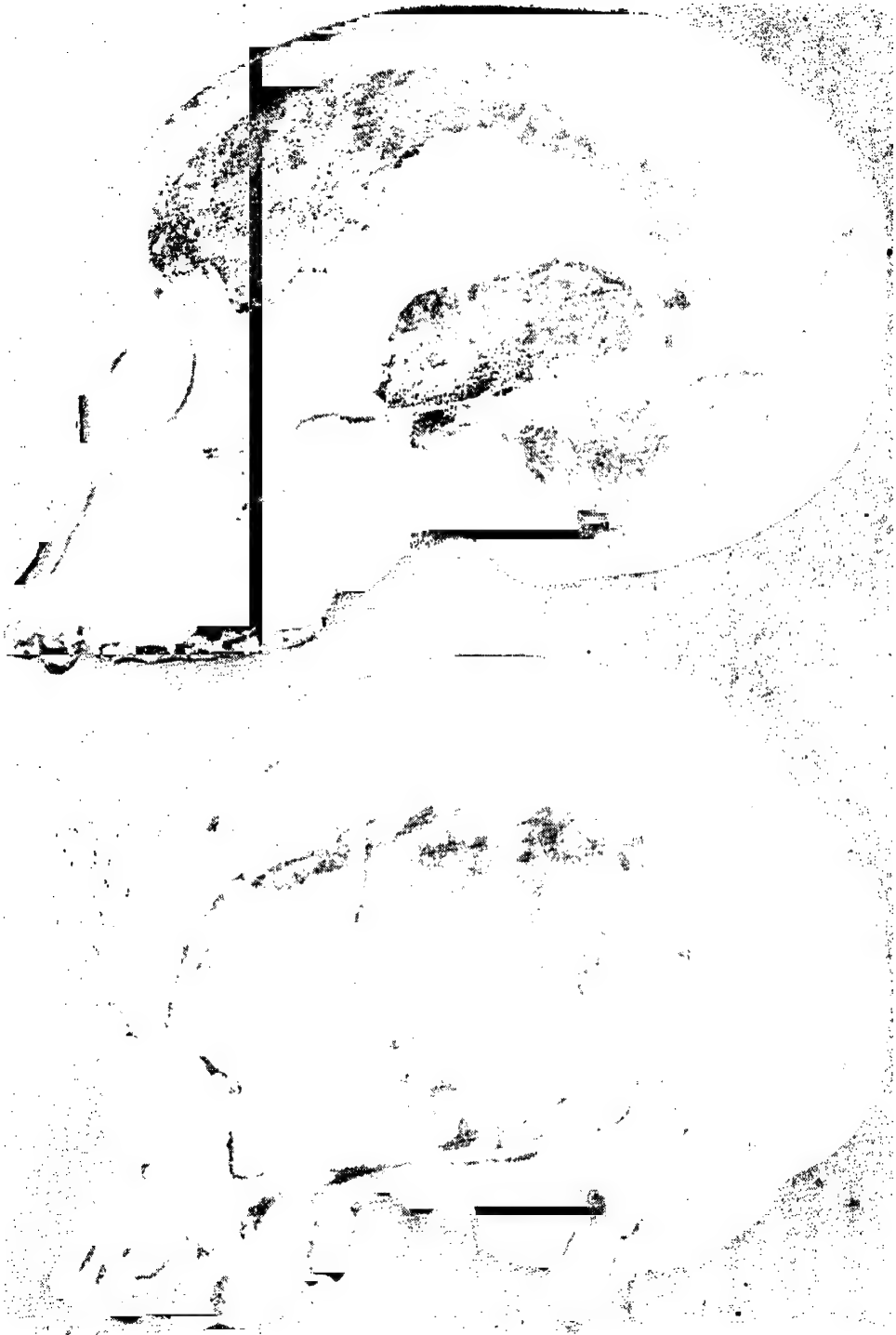
Secondly, and scarcely less important than the upright posture, was the change to full stereoscopic vision, a change which begins in the evolutionary scale in tarsius, the little tree shrew. By focusing both eyes on a single object, this alteration in range gave increased accuracy in sight and judgment, with a consequently increased stimulus to the development of the higher functions of the brain.

Thirdly came the opposable thumb, which by moving out of the plane of palm and fingers gave evolving man an inestimable advantage over the ape by making the human hand one of the most delicate and efficient mechanisms in nature. It provided an instrument for the accomplishment of the will and purpose of man which, as a supreme product of evolutionary adaptation, is capable with training, of making provision for all human needs and implementing most human desires.

These three factors have played preponderating rôles in the development of those qualities that have been responsible for the gradual building-up of man's civilization through the ages.

EVOLUTION AND CIVILIZATION

So much then is to be inferred from a comparative study of man and the great apes as they exist today. The salient fact which emerges is that if there are resemblances between them which point to a common ancestor, there are differences which are of even greater significance. In these differences are to be found the evidences of an evolutionary process, in the course of which a disparity in structure and function, and more especially in intellectual function, has developed between man and the great apes as a whole. By it man has been enabled to build up stage upon stage in the advancement of civilization, while his simian relatives have remained stationary in a



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SKULLS ANCIENT AND MODERN

Skull of the Piltdown man (top) and of a modern man. The brain-case of the Piltdown man is shaped much like that of a young ape, and the brain must have been of a very low kind. There are no bony brow-ridges. The projection of bone in the lower jaw forming a chin does not appear before modern man.

state of arrested physical and mental development.

At what stages in the line of common descent did these differences arise? When did man become specifically man, as opposed to the ape, and what were the causes which brought this about?

The answers to these central problems are only imperfectly known as yet, but when brought into relation with the studies of the archæologist, who seeks to trace the growth and development of man's arts and industries in the past, they go far to explain how each development in the evolution of man's form, acting and reacting on the development of his intellect, has enabled him to modify and exploit his environment to meet his needs, and thus to lay the foundations and build up the early stages of civilization, of which this modern world of ours is the outcome.

CHANGES IN GENERATIONS

Complex though modern civilization may be, it rests ultimately on the fundamental needs of humanity, needs which arise out of the biological urge of the struggle of the individual towards self-preservation and perpetuation of his race—our everyday quest to provide food, shelter and protection from outside danger for self and family group, which no less insistently was the day-to-day problem of our remotest ancestor.

In the study of the evidence for the origin and descent of man, two classes of facts have to be taken into account, the data of morphology, showing the changes in form which have taken place in the course of the evolutionary process, and the data of chronology, in which the evidence is arranged in order of time. This latter arrangement should show, if the interpretation is correct, the primitive forms as preceding in time the forms of more advanced type.

There may be exceptions owing to special circumstances, as for example when a degeneration has taken place instead of an advance in type; but as a general principle the rule should hold good that the earlier in time, the more primitive in type.

To appreciate clearly the relation to one another of the various examples of early types of primitive man which have been discovered, it is necessary that the methods by which these two classes of facts are handled should be understood.

Firstly, as regards the argument from morphology or the study of form. If we take an evolutionary series we find that in the course of generations of parents and offspring certain changes take place whereby the end-products or last generation, though clearly related, differ in various respects from the first pair, or original parents from which the series begins, as well as from one another.

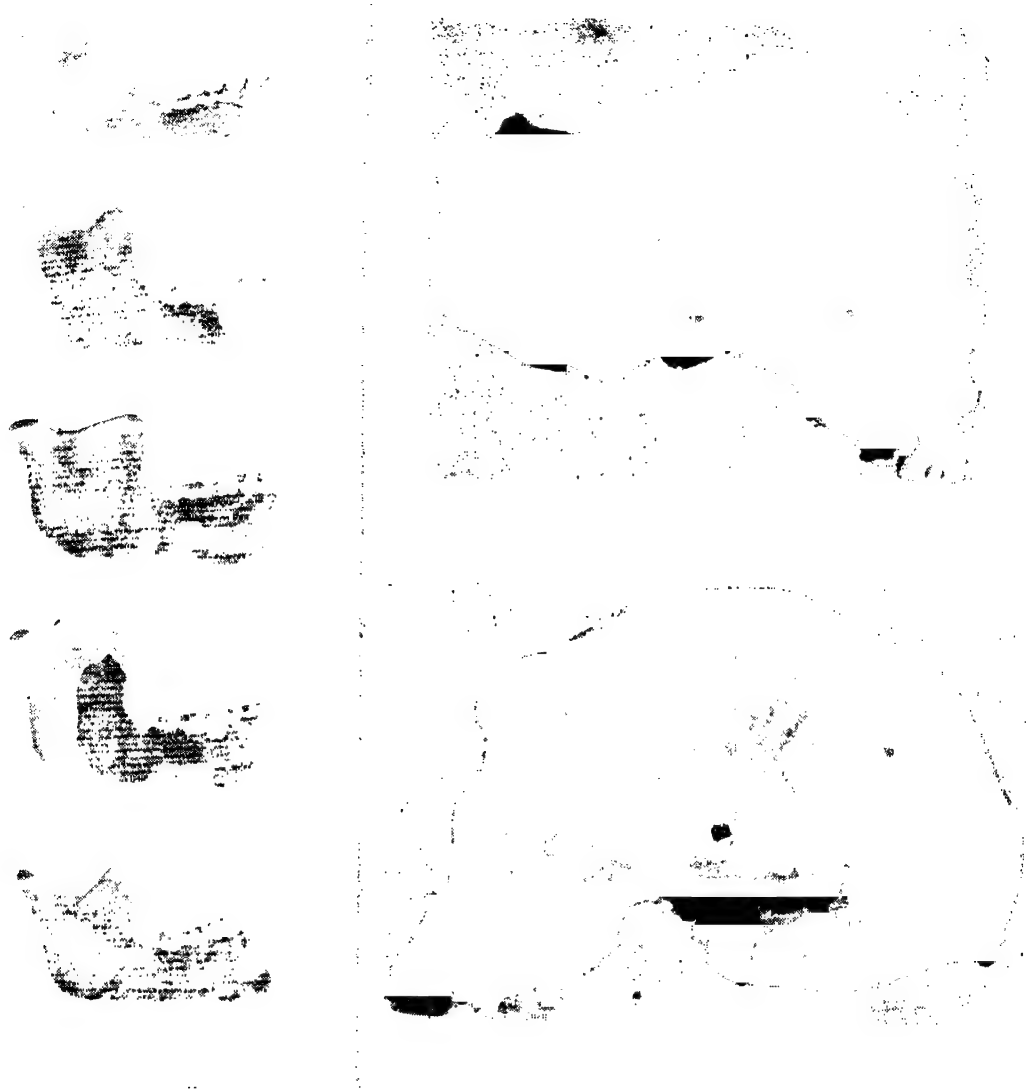
In examining such a series it will be found that change proceeds by modifying a generalized or generic type into specialized or specific forms. For example, a generalized type may have been modified to fit into a special environment, as the white coat of the Arctic fox has been evolved to match the background of snow, or the black skin of the negro is a differentiating character which affords protection against the actinic rays of the tropical sun.

* A simple illustration will perhaps serve to make the meaning clearer. Let a father and mother of five children be taken to stand for the generalized type. Each of the children bears a certain resemblance to the father and mother, but they are more or less sharply differentiated from one another. As generation after generation is born in descent from the original five children, each line of descent becomes modified from the type of the original parents, and at the same time more and more clearly differentiated from all the others. The differences mark each line of descent as a specialized or differentiated form. This can be shown in various ways, as by measurement, by description, or by photographs.

DATING EARLY MAN

If we had a complete set of such measurements or photographs for all members of all the generations, it would be possible to point in detail to the morphological changes by which the generalized type of the original parents has been modified to produce the specialized or differentiated types which constitute the end-products or final generation. Man and the great apes may be regarded as the final generation or end-products of such a family group of lines of descent. Unfortunately the original parents and many of the intermediate stages are missing.

It is the aim of morphological study of the living members of the family and such fossil specimens of both apes and early man as have been discovered, to puzzle out and fill in the details of the family tree, and at the same



EVOLUTION OF THE HUMAN LOWER JAW

BRITISH MUSEUM (NATURAL HISTORY)

(Left) Half of the lower jaw of a young chimpanzee, Piltdown man, Heidelberg man, Neanderthal man and modern man. (Top right) Neanderthal skull from Gibraltar; (below) Rhodesian skull from north-west Rhodesia.

time to arrive at some idea of how, in what way, and at what stages in development have arisen the differences by which the members of the family as we now know them are distinguished.

Let us turn now to the evidence of chronology. It is obvious that the various specimens of early man that are known—specimens that at one time or another have been found embedded in the gravels and clays which lie beneath the upper soils of the earth's surface, cannot by the circumstances of their discovery be dated by any usual system of chronology. Such systems require a fixed point from which to

start, such as the Christian calendar possesses in the birth of Christ; a time measure, such as the year—solar, lunar or calendar—and a method of recording, such as a body of numerical symbols, perpetuated in writing.

None of these exists for dating early man. The only means available for arriving at some idea of the antiquity of any given specimen of early man, and its relation in time to other specimens, is by examining carefully the character of the deposits in which the specimen is found, and comparing these deposits with others, with a view to determining their relative age.

It is essential, of course, that the deposits should not have been disturbed, so as to ensure that the specimen is of the same age as the deposits, and that the bones have not been introduced into them at a later date, for example, by falling into a rift in the ground, as some think happened to the remains of Rhodesian man in South Africa, or by burial. When the relation of all the known deposits or strata one to another has been determined, this gives a time scale by stratification.

TREASURE-TROVE IN REFUSE

Let us take as a simple illustration the method by which the archæologist works when excavating the remains of a city which has long been destroyed, and of which there are no written records. Suppose that near a village there is a refuse pit into which the inhabitants of the village have been accustomed to throw all their refuse for a period of hundreds of years. The refuse will include not only scraps of food, but broken domestic utensils and furniture, broken pots, tools and the like, as well as old bones. If this pit has been undisturbed, when we dig down through its contents we come first of all on the refuse of yesterday, then in succession to that of last week, last month, last year, and so on back through the centuries, until we reach the time when the village was first founded in the virgin soil at the bottom of the pit.

Now if the contents are taken out carefully in separate layers and sifted, and the contents of each layer kept separate and arranged in the order in time in which they were thrown away, as shown by the order of the layers or strata, it is possible to reconstruct a more or less complete picture not only of the history of the settlement, but also of the manners, customs, industries and arts of the inhabitants of the village at different periods.

What kind of cattle they had and the nature of their food will be shown by the bones and food refuse. How they dressed, and what material they used for tools and implements, when new fashions in material and form were introduced, and when old fashions died out—all these can be traced; and if the layers are numbered in order these changes can be dated accurately in terms of the time scale afforded by the sequence of layers.

Further, if we can form any idea of the period of years covered by each layer, it is possible to translate this time scale into terms

of years, and to say, for example, that a form of bowl which is found in the fourth to sixth layers was in use in a period extending from six hundred to four hundred years ago. The time series can be used also to date objects coming from another source altogether; for if any object can be matched with one in our series, it can be said to be contemporary with the layer from which the object from the pit was taken.

In dealing with the dating of the remains of early man the same procedure is followed, except that it is only in the later stages of his career that his remains are found preserved amid the refuse of human occupation, which affords us a clue to his way of life. This first occurs during the phases of what is known as the Old Stone Age, when man had learned how to flake flints to give them a keen edge, had taken to living in caves, and the bodies of the dead were either buried in the floor composed of the debris of occupation, or left there and abandoned to be worried by wild beasts and the remains covered by the wastage of time and later comers. A clue to the dating of the skeletal remains is then afforded by the character of the animal bones, implements and so on, which are found with them.

For most of the specimens of early man, and especially for the earlier examples, these aids to chronology found with the caveman are unfortunately lacking, and the clue to period must be deduced from the age of the undisturbed deposits in which the bones are found. These deposits, for the most part clays and gravels, often have been laid down by water, or by the action of the glaciers which formed the great ice cap covering the whole of the more northerly part of the globe in the Ice Age.

CALENDAR OF THE ROCKS

The rocks which compose the earth's surface, including these clays and gravels, have been studied by the geologist in the same way as the archæologist studies the layers of his refuse pit. They have been classified by him, according to the order in which the layers or strata lie one upon another, into great systems or groups, each group the equivalent of a geological epoch, representing a vast period of time, in which the deposits of that group were being formed.

Further, in each of these strata or deposits are found fossilized remains of animals and

plants, many or most of which are now extinct. Not only do these show, according to their kind, what the climate was like at that time, hot or cold, wet or dry, but as many of them are "characteristic" or "type" fossils, that is they are found only in certain strata and in no others, whenever they occur with other remains they serve as an indication of date.

They show that the remains with which they are so found in association must belong to the same period in the geological time scale as themselves. Thus if the bones of early man are found in gravels in which also occur the bones of the mammoth or the woolly rhinoceros, it shows that that man must have lived in the same period of the Ice Age as those monsters.

THREE IMPORTANT EPOCHS

In this classification into epochs of the rocks and deposits the student of early man is concerned only with the latest in time, the Tertiary epoch, the Quaternary and the Recent, the last named covering the deposits of the present era.

Of these the Tertiary epoch is divided into periods or stages, according to the number of certain types of fossils they include, the number



PROF. J. H. MCGREGOR

MODELLED FROM FRAGMENTS

Modelled on a restoration of the skull of Piltdown man from cranial and jaw fragments.

increasing as time progresses. Thus we get the Eocene or dawn stage, the Oligocene as these fossils appear in small numbers, the Miocene as they increase, the Pliocene when there are still more, and then as we enter the Quaternary epoch, the Pleistocene, when they reach their highest number, this stage in turn giving way to the "Recent" deposits as the Old Stone Age closes, perhaps eight to ten thousand years before the birth of Christ.

TIME SCALE OF MAN

This classification is of supreme importance to the study of early man because it gives the geological succession or time scale by which the antiquity of the remains of the different types of early man can be determined, according to the character of the deposits in which they have been found. Not only does this show how old they are in terms of geological time, but it also tells us which are earlier than others, and which lived at approximately the same time.

Up to the present no remains of early man have been found in the deposits of Tertiary



PILTDOWN MAN RECONSTRUCTED

The resemblance of the mouth and jaw to those of a chimpanzee is particularly noticeable.

age. It is in this period, however, that we should expect to find the common ancestor of man and the apes, for it is in the early phases of this period that fossil monkeys begin to appear. The remains of man actually known as the earliest come from the beginning of the Pleistocene stage.

For the greater part of this period much of



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MADE BY PILTDOWN MAN

Flint implements found with the Piltdown skull. One face is irregularly flaked round the edge.

the northern hemisphere was covered with an ice cap which oscillated or advanced and receded a number of times as the temperature varied. Accordingly we find that the remains of early man in Europe in this period are associated with fossil animals now extinct, some of which, such as an ancient type of elephant, must have demanded a hot climate, while others, such as the cave bear and the mammoth, belong to a period of intense cold.

Any attempt to translate these geological epochs into terms of years is little better than guess work; but it has been calculated that the earliest remains of man from the early or Lower

Pleistocene, at the beginning of the Quaternary epoch, cannot be much less than half a million years old. Some geologists are inclined to regard this estimate as too high, while others would increase it to near a million years.

Before passing on to consideration of the principal types of early man which have been found in various parts of the world, and their relation to one another, two questions require attention. Where and at what stage of development does man first appear?

WHERE MAN FIRST APPEARED

As regards the place of man's origin there is a sharp difference of opinion. Some authorities would place that event in Africa, others favour Asia. On behalf of Africa it has been argued—and this is the view to which Darwin lent his support—that as it is the home of the great forest apes, the gorilla and the chimpanzee, it is the most probable region for man's first appearance. The mere fact that the great apes have survived here is sufficient indication that the conditions of place and climate were favourable for such a development.

Further support is afforded by the occurrence of fossil apes of primitive type and early age in the Egyptian Fayum, while *Australopithecus* (from Latin *australis*—southern and Greek *pithekos*—ape), usually referred to as the Taungs skull, discovered at Taungs, South Africa, in 1925 by Professor Raymond Dart, comes so near the human line as to have been considered by its discoverer to be the “missing link” between man and the apes. It may indeed represent a stage of development corresponding to that at which man's ancestors were ceasing to be tree-dwellers. A later and still more advanced form was found by Dr. R. Broom in the Transvaal in July, 1936. Although now generally held to be a chimpanzee-like form, some authorities still regard the Taungs skull as within the line of human descent.

GIANT AMONG FOSSIL APES

On the other hand, there is much to be said for Asia as the region in which man evolved. In the foothills of the Himalayas known as the Siwalik Hills, the Miocene deposits have produced a large number of bones, the remains of fossil apes of various types. Of these *Dryopithecus* (from Greek *drus*—tree and *pithekos*—ape), particularly in types recently found by an American expedition, comes very close to the human line. This is shown especially in the form of the teeth, which have been classified by

Professor W. K. Gregory, of New York, as ancestral in type to those of both man and the great apes. *Dryopithecus*, which in size is a giant among the fossil apes, has also been found in the Tertiary deposits of France and on the Rhine.

APE-MAN OF JAVA

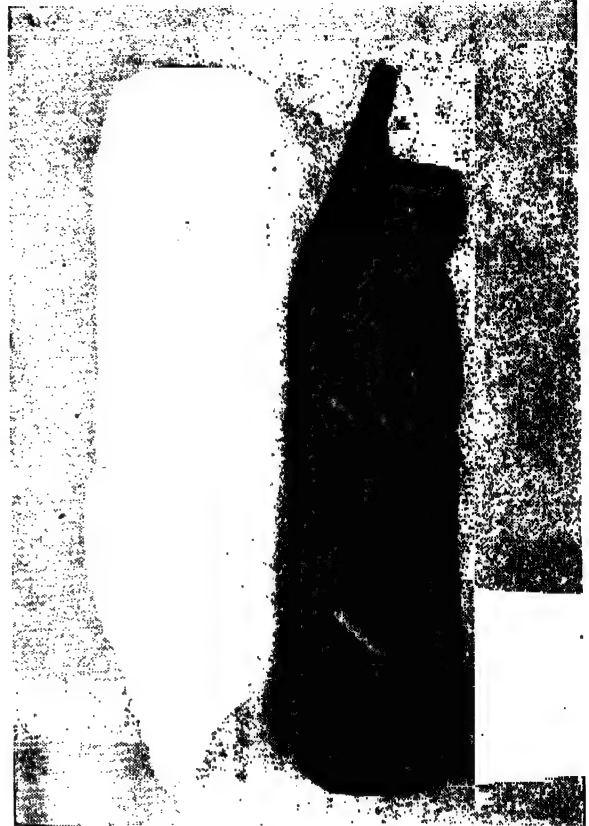
From the geological evidence, as well as the evidence of the fossils, obtained in the Siwalik Hill region by the latest expedition from Yale University, it would appear that at some time in the Tertiary period with which we are dealing a great climatic change took place which caused the tropical belt to swing from north to south. As a result the mammals of India, of which the fossils are now being found, migrated towards the south-east of the continent. This migration, it is thought, also had a crucial effect on the development of man. It is therefore not without significance that it is in this south-eastern area, namely in Java, that one of the earliest known types of early man, *Pithecanthropus erectus*, the ape-man of Java, has been found. Further, at about the same time as the climatic change in India there was a similar change in climate in China. This change drove out the sub-tropical animals and plants which had previously populated that part of the world, but it offered favourable conditions for succeeding waves of immigration of new forms from the north-west and the south with which man appears, probably from the south. The famous Peking man, *Sinanthropus* (from Latin *Sinensis*—Chinese and Greek *anthropos*—man) is a result of this immigration.

EARLY MAN IN ENGLAND

For these and other reasons it would seem that the balance of the evidence is in favour of Asia, and more particularly the southern portion of Central Asia, being regarded as the scene of the crucial stage in man's evolution. Some authorities would link the event with the change in the environment which took place at the great uplift of the central ridge extending from east to west, of which the Alps, Hindu Kush and Himalayas form a part. This tremendous happening may well have forced man's precursors to change from an arboreal to a terrestrial mode of existence. The ape descended from the tree and became man.

The assumption of the upright posture, even as a permanent habit, does not completely differentiate man from the ape. Man has been defined as a tool-using animal, but the

ape also will use a convenient stick, stone or other object with sufficient sense of purpose to justify the inclusion of the ape with man as at least an occasional tool-using animal. Man, however, is not only capable of making use of some material object to attain his purpose, but he alone of all living organisms also modifies the form of such object to his requirements. In



BRITISH MUSEUM (NATURAL HISTORY)

BONE IMPLEMENTS FROM PILTDOWN
The oldest known bone implement. It is made from a fragment of the thigh bone of a very large elephant.

other words, man is not only a tool-using animal; he is also a tool-making animal.

If this exercise of tool-making activity be accepted as the differentiating character of man it marks the stage of his transition from ape to man, as distinct from the sub-human. There is then reason to think that man came into existence and was widely distributed over the earth's surface long before the age of the earliest known human skeletal remains. These, as already noted, have not been found before the earliest phases of the Pleistocene. Stone implements, however, fashioned by purposive action to a definite shape and intended to meet a specific need, have been discovered in deposits

of the Upper Pliocene. Some experts indeed would say, for example, of the implements found in the late Pliocene deposits of East Anglia, that they are derived from an even greater antiquity than the deposits in which they are found, having been washed out of their original site by later floods.

While these implements suggest the existence



PROF. J. H. MCGREGOR

PITHECANTHROPUS

Head of Pithecanthropus modelled by Prof. J. H. McGregor on the restored skull. The remains were discovered between 1891 and 1894.

of man at a very early period and in the Tertiary Age, the violence of the convulsions of nature at this time affected geographical and climatic conditions to such an extent by the repeated rise and fall of the earth's surface, which changed the relative distribution of land and water, that it is improbable that such fragile relics as the bones of man would survive.

For one relic of early man, however, a claim for Tertiary Age has been advanced. Some of the gravels among which the fragments of the skull of Piltdown man, *Eoanthropus* (from Greek *eos*—dawn), were found in Sussex, as announced in 1912, were of Pliocene Age. But these relics came to light after the gravels had been dug out

and removed from their beds, so that it had become impossible to say with certainty what the original position of the skull had been. It could not, therefore, be dated without question, and is now generally considered to be of early Pleistocene Age. If this is correct, the Piltdown skull is approximately of the same antiquity as the two relics from the Far East already mentioned, *Pithecanthropus*, which was found in early Quaternary gravels of the Pleistocene at Trinil in Java, and Peking man, who was found in the cave of Choukoutien, near Peking, in deposits in which it was associated with fossils pointing to an early Pleistocene dating.

SKULL OF PEKING MAN

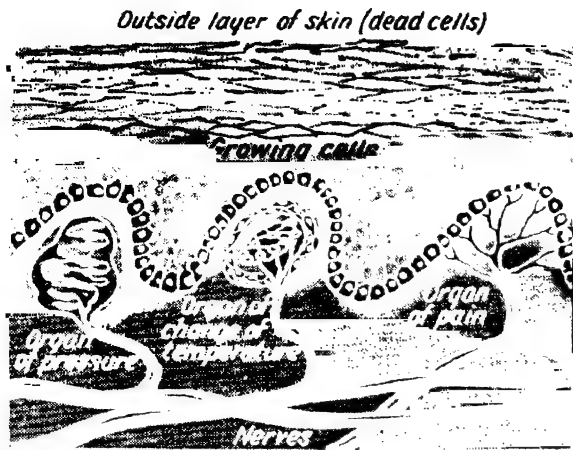
The remains of *Pithecanthropus* first found by Dr. E. Dubois between 1891 and 1894 consisted of a skull cap, thigh bone and tooth. Other bones were also discovered, but not described until many years later, while some details are still unpublished. The skull cap is of so primitive a form that doubts were long felt whether it were human at all. Dr. Dubois himself is still inclined to regard it as a gigantic gibbon, but it is now generally accepted as a very primitive human type, while the character of the thigh bone shows that this being walked upright, hence the addition of the word *erectus* in the full title.

The human character of *Pithecanthropus* is now supported by its resemblances to the later discoveries of Piltdown man and Peking man. The first complete skull of the latter was found in 1929; the latest specimens are three skulls discovered in the same cave in 1936.

FORESHADOWING MODERN MAN

It has been claimed that of skulls of early man found in Kenya, in East Africa, one may be approximately of the same age as Peking man and *Pithecanthropus*, but it is of a different type, a precursor of "modern" man. The claim to a high antiquity for man in this region, resting as it does on evidence which at present lacks corroboration, must be regarded as "not proven."

It is a remarkable and significant fact that the most primitive examples of early man should be derived from localities so widely apart as the Far East and Western Europe. If the numbers were not so small, such a distribution in itself would suggest a dispersal from a common centre such as mid-Asia. The occurrence of an early specimen of man in East Africa, notwithstanding the difference in type, might also



THREE ORGANS OF TOUCH

The bulbs at the nerve tips have specialized work to do because the end of each nerve fibre can only be excited by one kind of stimulus.

enable the eye to turn upward, downward, and to each side. The other two, slightly bent in their course and hence called the oblique muscles, run across the orbit and give the eyeball the power of rolling.

The eyeball is roughly spherical, but its front part projects in a slight bulge. The outermost of its three coats is the sclerotic, a tough and opaque white membrane which forms the hinder five-sixths of the sphere, and is partly visible as "the white of the eye." Let into the sclerotic in front, as a window is let into a room, is the transparent and slightly bulging cornea.

COLOUR OF THE EYE

Lining the inner surface of the sclerotic is the eye's second coat, the choroid, a pigmented membrane, plentifully supplied with blood vessels. At the border of the cornea it leaves the sclerotic and, as a circular coloured curtain, called the iris, extends across the eye at some distance behind the cornea. It is the iris which gives the eye its colour. Consisting of two layers of unstriped muscle, it regulates the amount of light entering the eye by expanding or contracting the circular hole, the pupil, which pierces its centre. No light can pass through the iris itself because of the black pigment which covers its back surface.

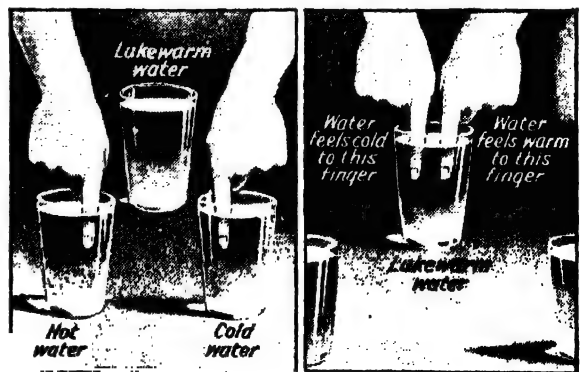
The innermost of the three coats of the eyeball is the retina, the most important structure in the eye. Sensitive to light, this serves as a photographic plate. Although it is only one-fiftieth of an inch thick, the retina is composed

of no fewer than ten cell layers. Nearest the choroid a layer of pigment cells keeps the light from spreading. Next to these comes a layer of highly-specialized cells which take in the light, the rods and cones as they are called. The cones are sensitive to the intensity of light; the more numerous rods, which contain a substance called the visual purple, enable colour to be perceived.

WHERE VISION IS CLEAREST

In the retina a small oval pit in the middle of the back of the eye is known as the yellow spot. At the centre of this spot only cones are present, yet it is here that vision is clearest: distinctness of vision, then, is due to the cones. At the point where the optic nerve from the brain enters the retina, the characteristic red colour of the latter is varied by a small oval patch of pale pink. Here there are neither rods nor cones. Consequently, this area is insensitive to light, and is termed the blind spot.

The low interior of the eyeball is divided by the iris into two unequal spaces called chambers. Lying between the cornea and the iris, the small front chamber contains a clear watery fluid, the aqueous humour; the large chamber at the back of the iris is filled with a transparent jelly-like substance known as the vitreous humour. The latter is hollowed out in front to take a double convex lens, called the crystalline lens of the eye. Unlike that of a camera, this lens is not a firm body, but consists of a transparent elastic tissue set in a ring of muscular fibre, the ciliary muscle, which, on contracting, causes the lens to bulge and so become thicker in the middle.



HOW THE SENSES DECEIVE US

Place a finger of one hand in hot water and a finger of the other in cold, then both in lukewarm water. The result will be as above.

It is this power of accommodation as it is called, which enables the eye to form images of both near and distant objects. As the photographer focuses his camera by altering the distance between the screen and the refracting lens, so the ciliary muscle by bulging the lens of the eye makes it thicker and so capable of focusing the divergent light rays from near objects, or by flattening it brings the almost parallel rays from distant objects into focus upon the retina.

HOW WE SEE

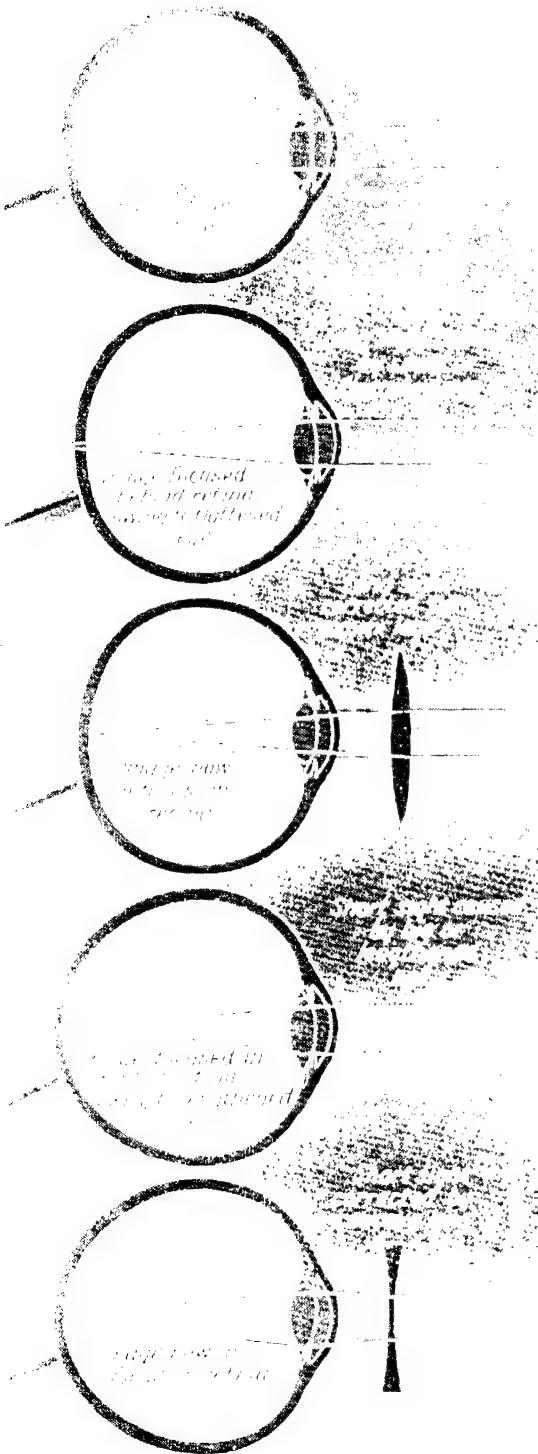
The mechanism of sight is briefly this : light falling upon the eye is concentrated by the cornea, then by the aqueous humour and finally by the crystalline lens, where it is properly focused. Traversing the vitreous humour, which also has a minor share in the focusing, its rays strike the retina, upon which they produce a small inverted image of the object seen. Light first meets the nerve fibres in the retina. The rods and cones, which may be compared to the touch bodies in the skin, are stimulated by the light. This affects the optic nerve, and impulses are sent to the brain, producing visual sensations.

The retina has the power of retaining images made upon it for a brief time—about one-eighth of a second. This explains why a mounting rocket gives the impression of a trail of light, while a glowing rope-end, rapidly whirled, produces the effect of a circle of light.

If a bright object is gazed at for a time, that part of the retina on which the image falls is soon exhausted. This may be tested by turning the eyes from the light to a sheet of white paper, when a dark spot or after-image is seen. This is an illusion, produced because the rays of light from the seemingly dark spot are in fact falling on the exhausted part of the retina.

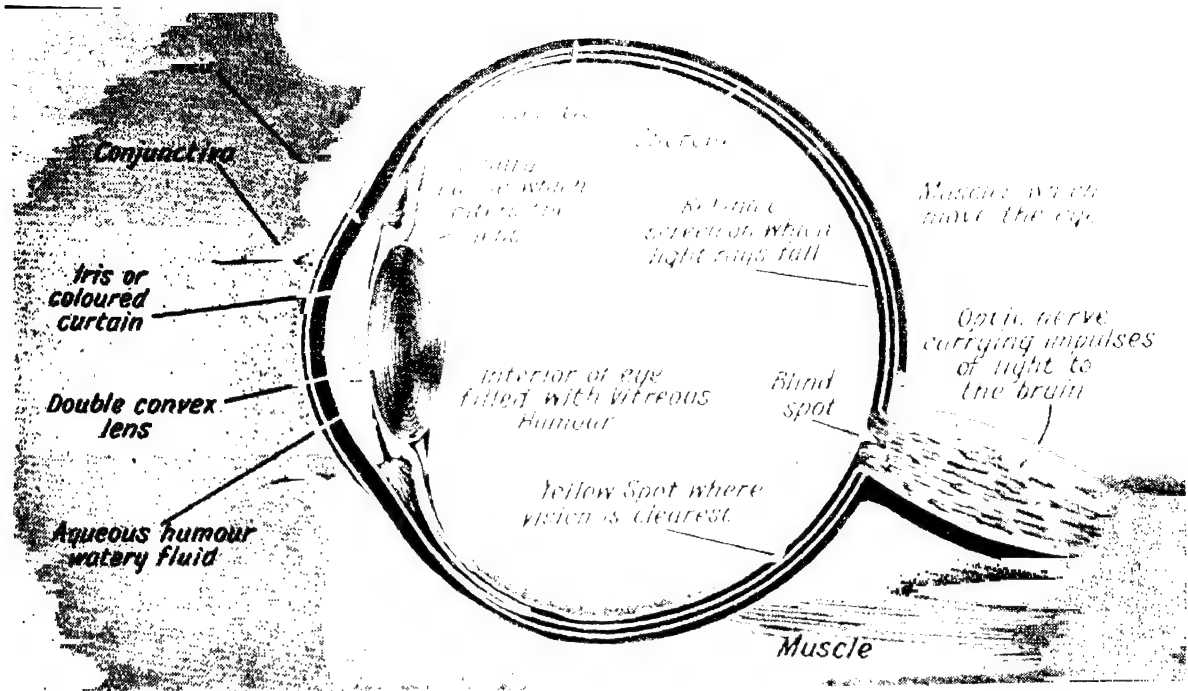
CAUSES OF BAD SIGHT

The comparison of the retina to a photographic plate may be carried further. In the same way as the light-sensitive layer on the plate changes chemically under the influence of light, so the visual purple is bleached. This bleached substance stimulates the rods to send impulses to the brain. The visual purple, however, has the capacity to regain its colour in a short time. Strong light falling continuously on the retina allows no time for this recovery. Consequently the retina becomes temporarily exhausted.



"LONG" AND "SHORT" SIGHT

Both defects can be corrected by spectacles with convex lenses and concave lenses respectively.



MECHANISM OF SIGHT

The retina has the power of retaining images made upon it for about one-eighth of a second. Light first meets the nerve fibres in the retina. Optic nerves carry impulses to the brain, producing visual sensations.

In the case of people whose eyes are too small and flat, or not sufficiently bulging, the rays of light are focused not on but behind the retina, and a blurred image results. This is known as "long sight." Eyes that are too big or too bulging focus the rays in front of the retina. Again the image is blurred; this type of defective vision being called "short sight." Both defects can be corrected by spectacles with convex lenses for long sight and concave lenses for short sight.

Each eye sees the object before it from a slightly different angle. But in spite of this we see only a single image. The nerve fibres of the right half of each eye unite and go to the optic centre in the right hemisphere of the brain; while the nerve fibres of the left side of each eye go similarly to the left hemisphere. In this way the stimuli from each eye become mixed and produce one image.

MECHANISM OF THE EAR

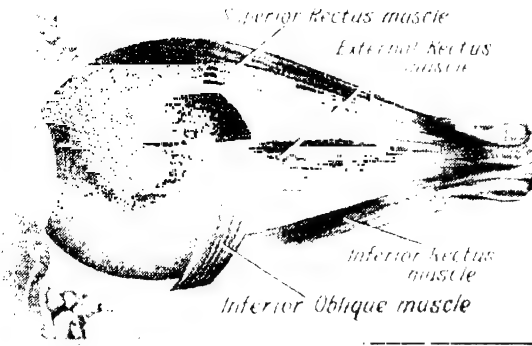
At the side of the head is the outer ear, a folded plate of cartilage covered with skin, leading into the skull by the auditory canal. Protected by the strong bones at the base of the skull lie the two chambers of the inner and the middle ear. The middle ear is

separated from the auditory canal by a tightly-stretched membrane, the drum or tympanic membrane, and from the inner ear by a second and similar membrane, the fenestra ovalis. The gap between the two membranes is bridged by the chain of three small bones, known on account of their shape as the hammer, the anvil, and the stirrup. The hammer fits into the tympanic membrane, and the stirrup into the fenestra ovalis.

WHEN WE FEEL GIDDY

In order that the drum may vibrate freely and transmit the vibrations to the small bones, the hollow in which these are placed must be kept full of air. This is provided for by a pipe called the Eustachian tube which connects with the back of the throat behind the air passages of the nose. If we have a bad cold, and the mouth of the Eustachian tube becomes blocked, the drum cannot vibrate properly, and temporary deafness often results.

The inner ear consists of two parts, only one of which has to do with hearing. The auditory nerve with its three thousand minute nerve rods suspended in lymph fluid, is protected by a bony tube, wound up like the shell of a snail. This bony tube, known as the



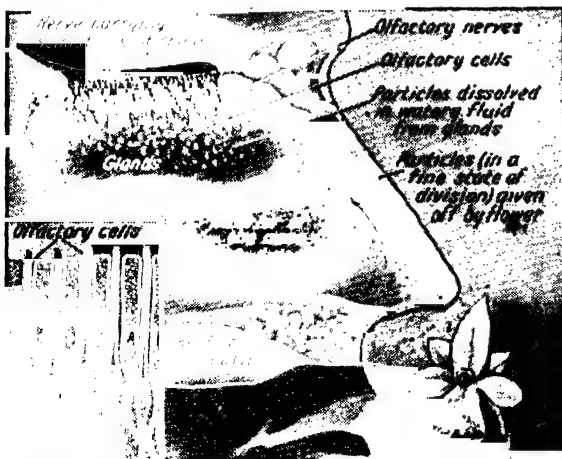
MUSCLES THAT MOVE THE EYE

The four recti muscles enable the eye to turn upward, downward, and to each side. The oblique muscles cause it to roll.

cochlea, is connected with the middle ear by the fenestra ovalis into which, as we have seen, the stirrup fits, and by the fenestra rotunda, an elastic membrane designed to give play to the vibrating lymph inside the cochlea.

Sound travels through the outer ear, which acts merely as a receiving horn, and, passing along the auditory canal, sets the whole apparatus into motion—the drum, the three small bones, the fenestra rotunda and the lymph inside the cochlea which finally excites the nerve endings. From these the impulse travels to the brain.

Inside the same chamber as the cochlea are three small curved tubes called the semi-circular canals. These, arranged in three planes, are so constructed that every movement of the body, up and down, right and left, backwards and forwards, is registered.



MECHANISM OF SMELL

How sensations of smell are carried to the brain from the perfume given off by a flower.

These tubes contain a fluid and are lined with sensitive hairs over which small crystals of carbonate of lime are suspended. These crystals change their place at every movement of the body, thus stimulating different hairs in different positions. The hairs, or nerve-endings, from the fluid are gathered into a large nerve running into the cerebellum. If a serious disturbance occurs in the semicircular



HAMILTON COLLECTION

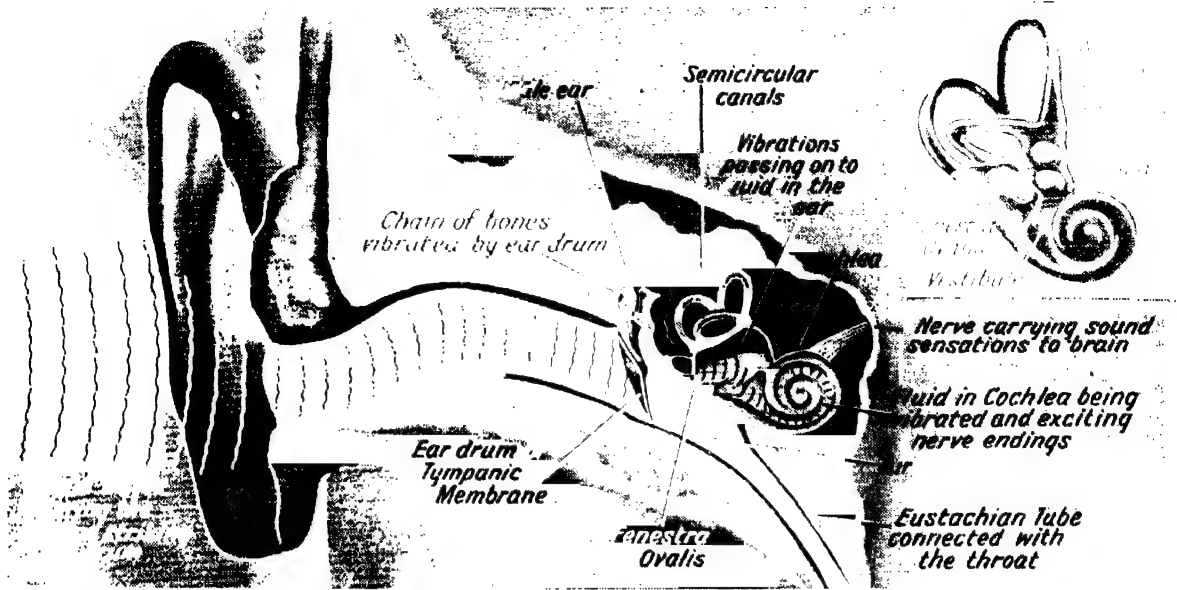
OPERATION ON THE EYE

As pictured in the first German manual on diseases of the eye, published in Dresden in 1583.

canals, our sense of balance is upset, and we probably feel giddy. Sea-sickness, train-sickness, and swing-sickness are all explained by this fact.

The organ of smell, like the organ of taste, is not so well developed in man as in other animals. Only about ten per cent of the work of the nose is concerned with smell. Although the other ninety per cent is made for the work of breathing, it is the ten per cent which decides if the air taken in is good or bad.

The part of the nose that does the work of smelling is found at the top of the air passage, under the root of the nose. At this spot is a



MECHANISM OF HEARING

Sound sets in motion the drum, the bones of the middle ear, the fenestra rotunda and the fluid inside the cochlea, which finally excites the nerve endings. From these the impulse travels to the brain.

patch of deep yellow mucous membrane, which is very sensitive to odours that rise to it. The appetizing flavours of coffee, grilled chop, tomatoes and so forth which set our salivary glands to work, are not really tasted at all; they are smelt by this delicate area lying at the highest and back part of the nose. Here the nerve fibres of the olfactory nerve branch out. When the nerve-ends are stimulated by odours, sensory impulses are transmitted to the brain.

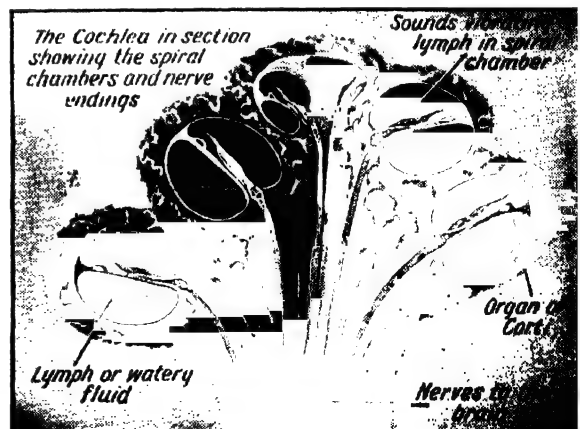
The organ of taste lies in the mucous membrane of the tongue, more particularly in its upper and back part, and also in the mucous membrane of the back part of the palate. The upper surface of the tongue is supplied with so-called taste buds, or papillæ, which are in contact with nerve-endings from the fifth and ninth pairs of cranial nerves.

The only substances that can really be tasted in the mouth are those that are sweet, bitter, sour, or salty. At the back of the tongue are about ten large papillæ, arranged in two rows like an inverted V. This is the part of the tongue that is able to taste bitter substances best; while the tip and the middle, which have smaller and redder papillæ, perceive sweet and salt tastes more readily.

The sounds we make in speech are the vibrations produced by the air leaving the lungs—which act as a bellows—and setting the

vocal cords in motion. These sounds are modified and enlarged by the chest, the mouth and the head, all of which serve as resonance boxes. The actual speech organ is the larynx, or voice box, i.e., the upper part of the wind-pipe reaching about one-third of the way down the neck.

This consists of four pieces of cartilage, to which the two vocal cords are attached. They are arranged that the cords can be stretched and relaxed by small muscles. The more tightly these cords are stretched and the smaller the gap between them, the higher



THE COCHLEA IN SECTION

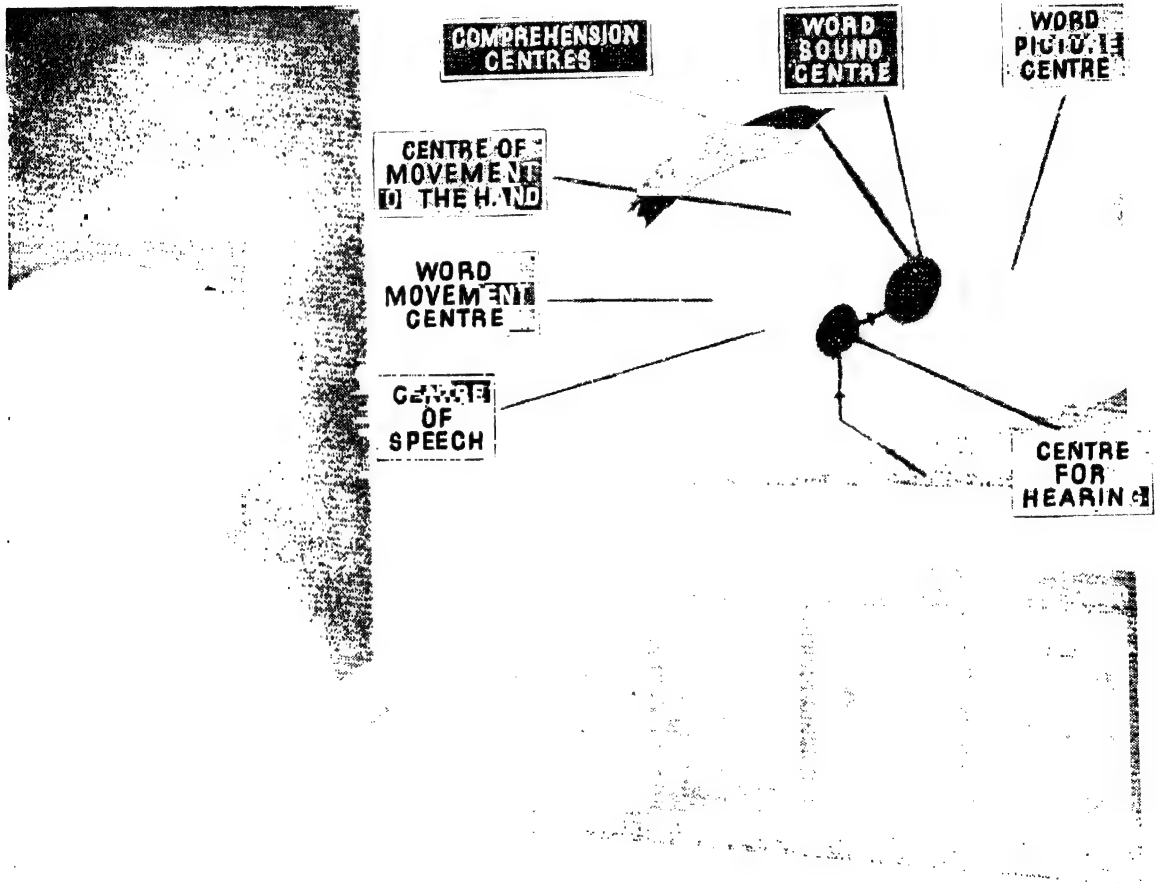
The cochlea in section, showing the spiral chambers and nerve endings vibrating in lymph.

and shriller is the tone emitted. The more relaxed the cords and the bigger the gap between them, the softer and deeper the tones.

The tongue, the jaws and the teeth, however, modify the tones produced. The vowels can be formed by the mouth alone without other help; the consonants by blocking in various ways the stream of air sent out by the lungs, thus: "s" is shaped by closing the teeth, "m" by closing the lips, and "n" by pressing the tongue against the teeth.

In speech and song many factors are involved: regulation of breathing, movement

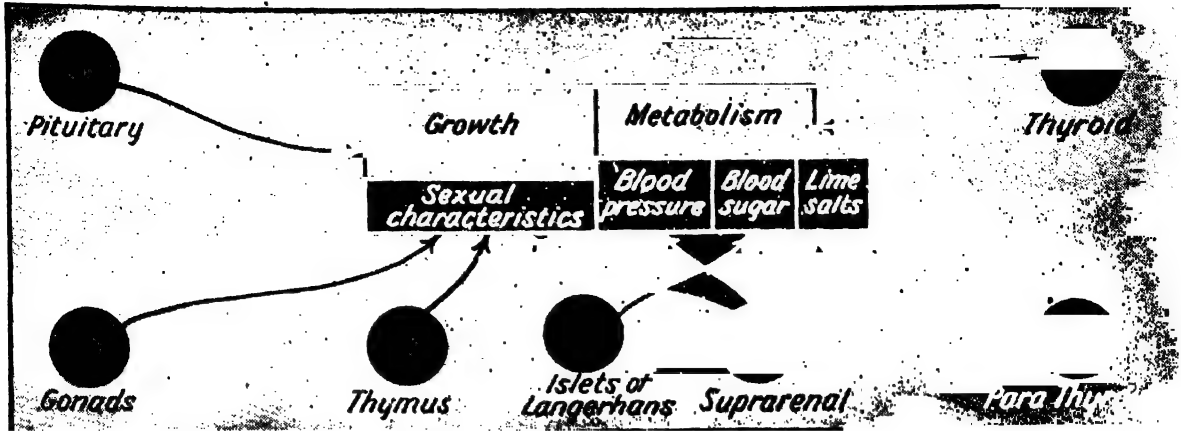
of the muscles in the larynx, movement of the tongue and cheeks are some of the most important of these. Thus, the spinal nerves which control respiration, and the cranial nerves which regulate movements of the face are in reality speech muscles. It is a pleasing thought that out of the waste air sent from the lungs man produces that wonderful thing, the human voice. When the larynx is defective in a mute the person must learn to swallow air and regulate its giving off so that by adjusting the position of the mouth speech may be produced.



BUFFALO MUSEUM (MONDIALE)

PHYSIOLOGY MADE SIMPLE

A wonderful exhibit in an American museum. It indicates the distribution of pathways and nerve centres in the brain in relation to speaking, writing, understanding and reading.



WORK OF THE DUCTLESS GLANDS

Effects on particular organs of various secretions passed out by ductless glands. They are so called because they pour their secretions straight into the blood instead of opening into a particular organ by means of a duct.

WHAT THE DUCTLESS GLANDS DO

ESSENTIAL to the well-being of both the body and the mind is the proper adjustment of the various systems one to the other. For instance, growth takes place in the human body up to about the age of fifteen, after which time there is a gradual slowing down, combined with a simultaneous development of the sex organs.

In order that these two processes may not become disproportionate, i.e., that sexual development may not take place too quickly and growth stop too early, or vice versa—the body is provided with a series of glands, known as the endocrine system. These glands have the peculiar characteristic of pouring their secretions straight into the blood, instead of opening into a particular organ by means of a duct. For this reason they are known as the ductless or endocrine glands.

The chief of these are the thyroid, the parathyroids, the adrenals, the islets of Langerhans, the pituitary, and the gonads (the testes and the ovaries which in themselves act as ductless glands).

The thyroid consists of a pair of oval-shaped bodies, weighing about one ounce and found one on each side of the "Adam's apple." The parathyroids are four pea-like organs in the vicinity of the thyroid. The adrenals, or supra-renals, are two small glands which lie just above the kidneys and are about one-seventh of the weight of the thyroid. The islets of Langerhans are areas, acting as ductless

glands, which are distributed throughout the pancreas. The pituitary, a small body weighing about one-sixtieth of an ounce and shaped rather like a flattened cherry, is situated on the floor of the brain.

The secretion of any of these glands contains a substance spoken of as the hormone, whose work is to stimulate a particular organ. For example, the larynx is so stimulated in males that that phenomenon, the breaking of the voice, takes place.

The endocrine system is only just being understood. Such knowledge as has been gained has largely come about through the removal of those seemingly unimportant structures, the glands. In many cases the results have been unexpected. For instance, the thyroid has been totally removed in an attempt to cure goitre. After its removal, the patient gradually became bald, stupid, thick-skinned and pot-bellied, showing that a very vital mechanism had been interfered with. It was discovered that the giving of iodine, or alternatively of thyroid extract, in small doses could better this condition brought about by the removal of the thyroid.

This went to show that thyroxin, which is the name given to the active principle of the thyroid, is necessary to the well-being of the individual. In countries such as New Zealand and Switzerland, where the soil is deficient in iodine, the thyroid cannot produce sufficient thyroxin, and goitre develops. In Switzerland

it is obligatory to mix minute quantities of iodine in the table salt as a corrective for the deficiency.

When the thyroid is over-active, the burning up of the carbohydrates in the body goes on much too fast. The person loses weight, and the heart is overtaxed. Finally, the thyroid gland becomes exhausted, when collapse or death results.



HAMILTON COLLECTION

FAMOUS IRISH DWARF

Owen Farrel, whose height was 3ft. 9in. Under-functioning of the pituitary gland leads to dwarfism.

When the parathyroids have been accidentally removed in an operation on the thyroid, it has been found that after five or six days, tetanus, or severe cramp of all the muscles, attacked the patient. Death shortly followed. The blood was discovered to be seriously deficient in its calcium content, and this was the cause of the tetanus.

The adrenals have the fourfold function of regulating the blood pressure, of regulating the supply of glucose or blood sugar, of counteracting fatigue, and of influencing normal sexual development. The blood pressure is regulated by the action of the hormone adrenalin, from the adrenal glands, upon the capillaries; this makes them contract. Incidentally, this is one means by which the body temperature is regulated.

The adrenalin acts on the glycogen in the

liver, and the glycogen is turned into glucose or blood sugar. When an extract of the adrenals is injected into a normal person, he becomes much more active and less liable to fatigue. The influence of the adrenals on sexual development is as yet imperfectly understood, but their work is thought to be connected with that of the pituitary.

BOY NINE FEET TALL

The islets of Langerhans secrete a substance, insulin, which enables the tissues to take up the glucose manufactured in the liver under the stimulus of the adrenal glands. People whose blood is lacking in insulin are unable to make use of the glucose. Consequently, the blood has much too high a sugar content, a condition that is known as diabetes mellitus. Since the tissues do not get enough glucose, they become undernourished and are not able to function properly. The patient grows weaker and weaker, since he is unable to utilize the carbohydrates in his food. With the discovery of insulin it has become a comparatively simple matter to cure diabetes by injection.

The pituitary has two lobes, each with three distinct functions. The posterior lobe regulates the flow of urine, causes a contraction of the uterus in parturition, and has a certain influence on the blood pressure. The anterior lobe regulates growth, controls sexual development, and has a slightly stimulating effect on milk production. Although the secretion, comparable to the thyroxin in the thyroid, has not yet been isolated chemically, it is thought to be some kind of protein.

REGULATION OF GROWTH

The best understood function of the pituitary is its regulation of growth. Under-functioning of the pituitary leads to dwarfism and sexual under-development known as infantilism. Over-functioning during early youth leads to gigantism. There is a case on record of a boy of eleven who weighed two hundred and fifty pounds and who was about nine feet high. A recorded case of dwarfism is that of a girl of nine and a half who was only thirty-five and a half inches tall and who weighed twenty-seven and a half pounds.

When either under- or over-functioning takes place, there is also sexual under-development. If, after maturity is reached, the anterior lobe of the pituitary begins to function excessively, the condition known as acromegaly is brought

about. Only those parts still capable of growth—i.e., the hands, the feet, the face, especially the chin and nose—are affected. The features become coarsened and enlarged, and the hands and feet grow excessively big.

THAT TIRED FEELING

When the hormone from the anterior lobe of the pituitary is insufficiently secreted, an obese condition is brought about. The Fat Boy of the *Pickwick Papers* who is always wanting to sleep can be explained on this basis.

In addition to the specific functions of the pituitary gland it also exerts an influence on the thyroid, the adrenals, and the gonads, though to what extent is not yet fully understood. In one sense its rôle can be compared to that of the brain in its relation to the nervous system. For it is the dominant gland of the endocrine system.

The ovaries and the testes, called the gonads in relation to this system, secrete substances which influence the development of the secondary sexual characteristics. In the female the hormone known as œstrin regulates the processes of menstruation and ovulation. When a ripe ovum is fertilized, the shed Graafian follicle (which, as we saw in the chapter on Reproduction, previously surrounded the ovum) grows out into a body called the corpus luteum. This then secretes a hormone called lutein which inhibits, or prevents, further ovulation and therefore further menstruation. It also stimulates the mammary glands to secrete milk.

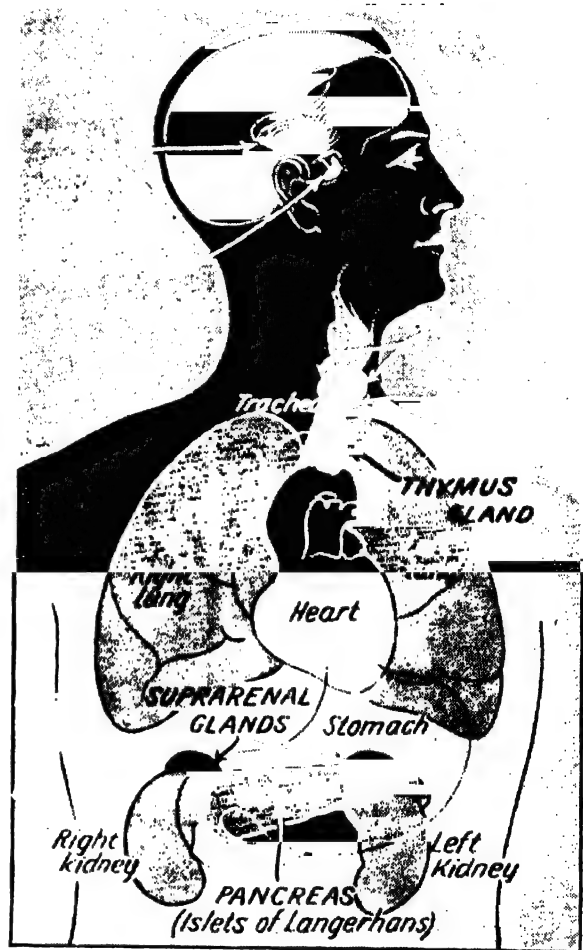
In pregnant women, œstrin and another hormone similar to that from the anterior lobe of the pituitary gland are excreted in considerable amounts in the urine. This fact has been used to ascertain during the first weeks whether a woman is pregnant or not. This is the only real test, since all other indications are but conjecture.

INFLUENCE ON TEMPERAMENT

The hormones from the ductless glands, because of their influence on the body, are also partly responsible for what we conveniently term the temperament of a person. For example, a slight over-functioning of the thyroid is characterized by vivacity, while an under-functioning gives a corresponding dullness. When our knowledge of the endocrine system is much greater, it may well come about that we shall be able to explain our various moods in terms of this or that gland

functioning or otherwise failing to function.

It was thought at one time that Voronoff's operation—the transplanting of testes—would overcome the symptoms of old age. This today, after much re-examination, is very much doubted. The operation has been found to produce temporary improvement only, and the same result has also been obtained in a number of other ways. The same conclusions

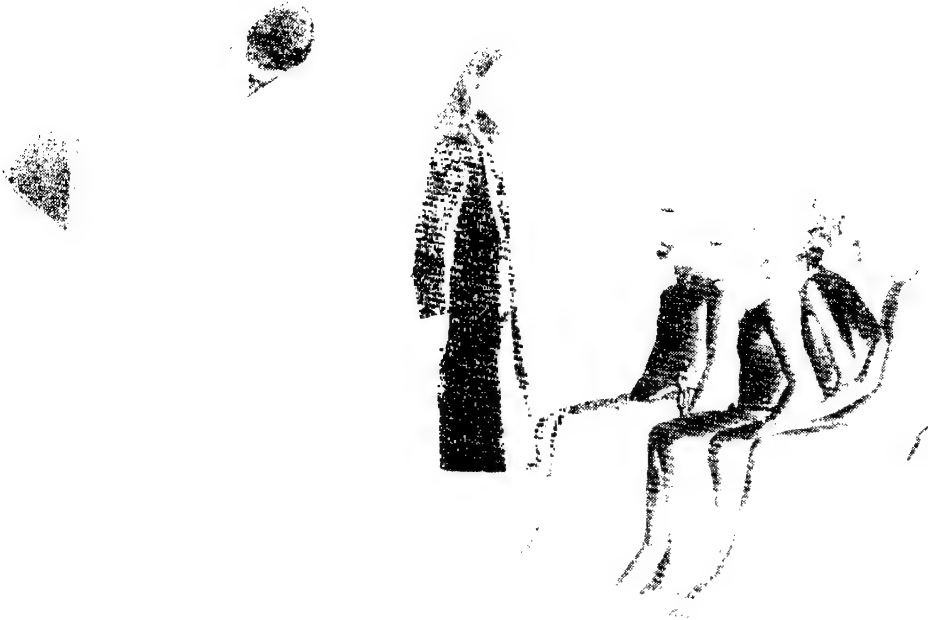


POSITION OF THE DUCTLESS GLANDS

The secretions of the ductless glands contain a substance spoken of as the hormone, whose work is to stimulate a particular organ. They are also partly responsible for temperament.

have been reached with regard to Steinach's operation, which was at first looked upon as a triumph for endocrinology, making rejuvenation possible.

Much work is still being done on these problems, and it is confidently expected that a great deal of new material will be available in the near future.



“SUNLIGHT IS THE GREATEST PREVENTIVE OF DISEASE”

So says Sir Bruce Porter, and these little people are basking in artificial sunlight. By using a combination of lamps it is possible to make use of any of the rays of sunlight in any desired proportion.

THE CONQUEST OF ILL-HEALTH

IN *Erewhon*, Samuel Butler depicted a community in which illness was treated as a crime and the sick sentenced to terms of imprisonment. The conception is satiric, but the satire has a sting of truth in it. We do not yet try a man for having a boil upon his neck, find him guilty of rheumatism, or give him twenty-eight days without the option for contracting a cold. But we do increasingly realize that Public Enemy No. 1 is ill-health; that the depredations made by sickness upon both the private and the public purse are many times greater in a single year than those of burglars and thieves in a generation; and that, whether or no the love of money is the root of all evil, health is most certainly the seed of the greatest national and individual good.

While the old fatalistic attitude that sickness is the will of God has long since been abandoned, science endorses most emphatically the belief

that disease is the punishment of sin—if by sin is understood that social sin which takes the form of bad housing, bad drains, poor nutrition and lack of adequate fresh air and sunlight.

The cost of ill-health to the nation is staggeringly high. In recent years the reports of the Chief Medical Officer of the Ministry of Health show that annually among the insured workers of the United Kingdom alone some twenty-six million weeks' work (half a million years) is lost through sickness. Even this huge figure—the equivalent of the loss of a year's work of five hundred thousand people—does not include loss due to sickness for which sickness or disablement benefit is not payable. Assuming the average wages of the half-million to be as low as £2 per week, the direct loss in wages to registered workers amounts to £50,000,000 annually.

Ill-health is not restricted to any one class.

The loss in earnings to those outside the scope of National Health Insurance is probably underestimated when it is given as another £50,000,000 each year. Then there is the expense involved in the care of the sick during the period of their incapacity. Some fifty thousand doctors practise in Great Britain; many thousands of chemists and pharmacists prepare the medicines these physicians prescribe. The voluntary hospitals alone spend some £10,000,000 yearly. In short, a conservative estimate of the annual expense entailed in the care of the sick is £100,000,000. There needs to be added the huge sum spent on patent medicines. More or less worthless as many of these are, it is calculated that no less than £150,000,000 annually goes to purchasing them.

APPALLING COST OF ILLNESS

Ill-health, then, costs Great Britain some £350,000,000 each year. It is reckoned that two-thirds of this sickness is preventable.

So far, so—bad. But there is a brighter side to the medal. In a score of different fields, both nationally and locally, measures are being taken first to discover the conditions which affect the health of the individual adversely and, secondly, to remedy them, or at least to modify them so that the effect on health is less harmful.

In industry preventive measures have been widely applied. They include the prevention of accidents. Beginning with that of 1897, a number of Workmen's Compensation Acts have been passed. All these are based upon the excellent principle that the cost of injury must be borne by the industry concerned, thus making it to the financial advantage of an employer to reduce accidents to a minimum. As a consequence, safety devices have been installed in works and factories, and regulations enforced to prevent workers from taking risks.

INDUSTRIAL DISEASES

Certain occupations, owing to the nature of the goods handled or the processes used, give rise to diseases—industrial diseases, as they are called—which often end in death or disablement. Throughout this country, aided by proddings from the Trade Union movement, the public has steadily developed a conscience in regard to these. As early as 1901 the Factory and Workshops Act required that the Home Office's Chief Inspector of Factories should be notified of all cases of anthrax and of industrial arsenic, lead, phosphorus and mercury

poisoning, and that sufferers or their dependants should be compensated. Since then the Home Secretary has, by means of orders laid before Parliament, extended the list of compensatable diseases to include poisoning by aniline, benzene and carbon bisulphide, together with cases of toxic jaundice, chronic ulceration and other skin complaints due to occupation.

PREVENTION BETTER THAN CURE

The effect of the law has been, salutary in many trades. Thus, among mule-spinners a cancer of the skin is frequently set up because the workers are in constant contact with crude oils. Today, this kind of cancer is to a very large extent being prevented by the substitution of a vegetable oil for the mineral oil previously used.

Skin diseases that originate in industry are very numerous. Even now, about forty chemicals are in use which are known to cause eruptions of the skin, unless precautions are taken against this. Since new industrial processes are constantly being introduced in which new chemical combinations are employed, modern medical science is engaged in a constant study of the effect of these on the workers who handle them.

OCCUPATIONS THAT CAUSE ECZEMA

Roughly, one in six of all cases of eczema in this country is the result of the occupation followed by the sufferer. Metal workers and operatives in engineering works contract a particular type of eczema—an eruption which breaks out on the hands and wrists, and which, like "mule-spinners' cancer," is due to the mineral oil used. A somewhat similar kind of eczema attacks flax workers who steep the flax in water; while a more serious variety, somewhat resembling smallpox in that it pits the face and arms, is often developed by the "doffers" who remove the spun linen from the frames.

Baker's itch is, of all occupational eczemas, perhaps the most difficult to cure. Small blisters break out on the hands and arms of those who mix the dough; later, these blisters suppurate and spread the infection.

Men affected are often compelled to stop away from work for six months and more, while there is frequently a recurrence of the malady. Medical research has gone to show that none of the ingredients used in baking bread and in making confectionery are injurious to the skin when they are applied dry, but that a number of them cause skin trouble if wet.

The Bakers' Welfare Order of 1927 was drawn up with this particularly in mind. Among other things, it compels employers to provide the necessary washing facilities so that workers may remove all dough and sugar from the skin before leaving work, and insists on immediate medical treatment on the first sign of the outbreak of skin trouble.

To turn from skin diseases to metallic poisoning. Lead, made use of in well over one hundred different trades, is of all metals employed in industry the most dangerous to the health of the worker. Lead poisoning, or plumbism, is liable to attack plumbers and painters (both house and ship), operatives in white lead factories, workers using lead glazes in the manufacture of china and earthenware, file cutters and enamellers—but, strangely enough, not lead miners.

LESSENING THE RISKS

The principal symptoms of plumbism include anæmia—caused by a reduction of the number of red blood cells and a consequent deficiency in hæmoglobin—abdominal pain, sickness and defective vision. Dropped wrist, due to paralysis of the muscles of hand and wrist, is one of the worst features of the disease.

The Lead Paint Act of 1926 forbids the use of lead compound except as paste or paint, and prohibits the rubbing off of old paint with pumice stone, directing that, for this, one of the "wet" methods of removal shall be substituted. Paint spraying is made illegal in the interior of buildings. Employers are compelled to provide washing facilities, and to arrange for the regular medical examination of workers, who must be suspended if found suffering from poisoning. Further, the employment of women or young persons in lead painting is forbidden. In most factories where lead processes are employed, workers lessen the risks by wearing tight-fitting overalls, making use of masks when the air is dust-filled, and by taking hot baths and changing their clothes before leaving work. As the result of these various measures, plumbism has very greatly decreased in the last thirty years.

In the potteries, while there is some plumbism among lead-glaze workers, far more sickness is caused by the inhalation of fine particles of flint; this renders the soft tissues of the lungs hard and inelastic. Where this condition, known as silicosis, is present, tuberculosis can much more readily gain a footing. Now that

radiographic examinations have made clear the nature of the disease, practical measures have been adopted to prevent it. Factory furniture is made, when possible, of material impervious to dust, and the walls and floors of workrooms are frequently washed.

AFFECTING TEXTILE WORKERS

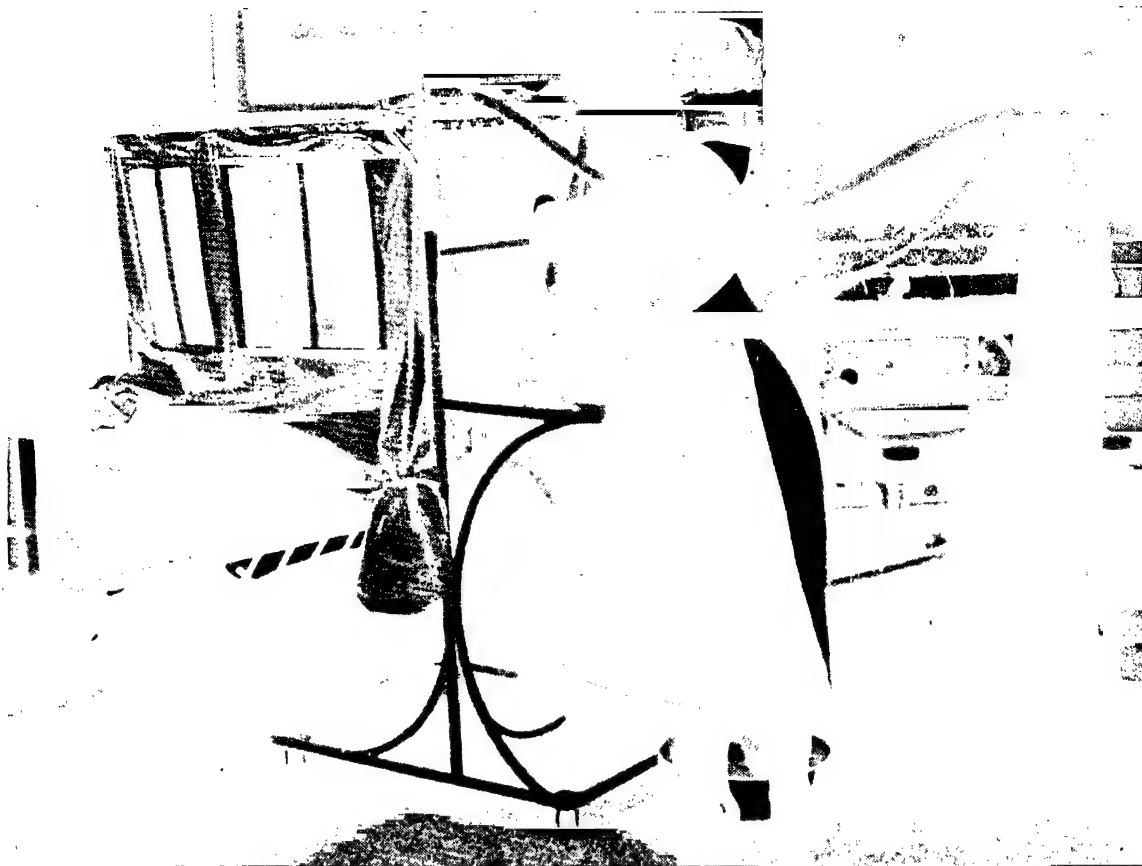
Respiratory diseases brought about by dust affect textile workers also. When cotton bales arrive at a factory, they contain considerable quantities of dust. If the bales are opened by hand, the air becomes thick and the workers' breathing is affected. Irritation of the mucous membrane is set up, and the lung tissue impaired. But today this unpacking by hand has been superseded to a large extent. Mechanical bale breakers are employed which, furnished with exhausts, keep the air reasonably clear. Dust causes trouble in cotton carding rooms also, although this is not of a respiratory nature. Boxes set beneath the carding machines to collect dust shaken out during the process are emptied and cleaned by the operatives. These workers often develop asthma.

A much more serious illness following upon inhalation of dust is anthrax or wool-sorters' disease. This dust harbours a rod-shaped germ, the *Bacillus anthracis*. Within a few hours of infection a disease resembling a virulent type of pneumonia develops, and death frequently takes place in less than a day.

DISINFECTING STATION

In the past the main source of the disease was infected wools imported from Asia and Asia Minor. The Government established a disinfecting station at Liverpool for foreign wools. This has proved a most successful preventive measure, for no known case of anthrax has followed the handling of wool dealt with by this station. Anthrax, usually of a milder nature, is from time to time developed by workers in the hide, skin and fur trades, and by employees in factories manufacturing hair and shaving brushes.

A curious form of intoxication, similar to alcoholic intoxication, mental excitement, an unsteady gait, and in the more extreme cases a paralysis of the limbs, afflicts workers in rubber industries or in factories manufacturing artificial silk from cellulose, because of the extensive use by both of carbon bisulphide. Makers of precision instruments and men using nitrate of mercury in the preparation of rabbits' skins for hat-making are liable to mercurial poisoning.



FOR THE ADMINISTRATION OF OXYGEN

FOX

An oxygen tent in which the gas is given to a patient in danger of suffocation or who for some other reason requires an aid to breathing. Before the invention of this valuable apparatus it was usual to administer the gas by means of a mask. The supply is obtained from the cylinder on the right.

And so the long catalogue of industrial diseases goes on. It is impossible to describe them all. In dealing with some of them preventive measures have had notable success. Thus, that form of gangrene known as "phossy jaw" once prevalent among match-factory workers who used white phosphorus has now disappeared owing to the substitution of sesquisulphide of phosphorus following upon the law passed in 1910.

SCIENTIFIC ADVISORY COUNCIL

Where no such simple solution has been possible, improvement of general conditions has done much. Underground workers, for example, suffer from both fumes and dust. The better the ventilation, the less the suffering. Hence, electric suction fans have been installed in mines and respiratory diseases have decreased among miners in consequence. In 1937 the Trades Union Congress, in the interests of the

workers it represents, established its own Scientific Advisory Council to obtain help and advice from leading scientists on problems of workers' welfare.

RHEUMATISM IN CHILDREN

In England there are two diseases—rheumatism and tuberculosis—which, unlike the special occupational maladies, affect practically every section of the community, and research to discover preventive measures applicable to these has accordingly been intensified.

Rheumatism is a constitutional disease, since the predisposition is strongly hereditary. For its successful prevention, therefore, the children coming of rheumatic stocks must be kept under observation, preferably from the age of two onwards.

The rheumatic child is easy to detect. He is usually highly nervous; his temperature is often abnormal. His skin, which is frequently

too dry, is unable to adapt itself to changes in temperature and humidity. Among research workers on rheumatism many hold the view that the children most liable to develop rheumatism are those who have some thyroid disfunction. As yet, there is not sufficient proof, however, that the two are linked.

"Growing pains," which in the days of our grandmothers were dismissed as natural in all children, are the first warning signs that

the iodine in the thyroid gland are at their lowest. Without exception, growing children need a good supply of calcium; with rheumatic children the need is doubled.

HARDENED TO THE CLIMATE

From early childhood the children of rheumatic parents in Great Britain should be gradually hardened to the very varying climate. After their warm baths they should become accustomed to cold spraying to tone up the skin, followed by vigorous rubbing with a rough towel. Their clothing should be warm and light, allowing the air to circulate freely.

Damp clothes—damp shoes in particular—and damp rooms must be avoided. Cold dry air is good for these children, and they should be encouraged to move about briskly whenever they are out of doors. Rheumatic children are especially liable to sore throats and colds; to a large extent, these can be warded off if windows are kept open and damp is avoided.

"Growing pains" usually occur in the muscles. The muscles, then, must be exercised in order to burn up excess fuel taken in as starchy and sugary foods. But it must be kept in mind that rheumatic children become fatigued more quickly than their more solidly built brothers and sisters. They usually have quick brains and are easily excited. Accordingly fatigue, both mental and physical, must be guarded against.

HEART DISEASE PREVENTED

St. Vitus's dance, one of the forms which rheumatism takes, is all too common among poor children who, having a lowered resistance to begin with, often do not get sufficient rest. All children with "growing pains" should be put to bed and kept there under the supervision of a doctor. If this is done, heart disease will often be prevented, or its progress checked.

When rheumatism has been contracted, it is essential that it should be kept under control. For once having developed, it recurs—or is prone to recur—not once but many times throughout life. More than half the cripples we see today owe their disability to rheumatic afflictions which would have been avoided had measures been taken against the rheumatism in its earliest stages.

It is this early control which preventive medicine seeks to secure over rheumatism today. Much has already been done. The Red Cross, for example, has established a special research department for rheumatism. A great number



ELLIOTT AND FRY

MADE OPERATIONS SAFER

Lord Lister (1827-1912), who introduced antiseptic conditions into the technique of surgery. Previous to his discovery most of the major operations ended in the death of the patient.

rheumatism has begun to attack a child. Since about eighty per cent of children who develop rheumatism develop heart disease in addition, these warning pains cannot be disregarded. Once rheumatic heart has been contracted, the sufferer is under a severe handicap for the rest of his days. It is for this reason that in rheumatic fever patients are kept lying flat in bed for at least six weeks, and after their convalescence protective measures are advised.

Children with a tendency to rheumatism should, above all others, have a well-balanced diet with a particularly liberal supply of vitamins and minerals. In winter such a diet is especially important, for it is at this season in the year that the calcium in the blood and

of treatments have been devised. They vary from the application of heat by high-frequency currents useful in relieving pain in muscular rheumatism to the vaccine treatment sometimes given in cases of osteo-arthritis.

Hot-air baths, mineral baths and Turkish baths have all been found to have value according to the form taken by the disease. Numerous drugs, plasters and poultices have been experimented with, and useful discoveries made especially in regard to iodine and its beneficial effects. Massage courses have been perfected, and the effect of artificial sunlight and regulated sun-bathing investigated.

MOST TOWNS HAVE CLINICS

At Peto Place, London, is the Red Cross Clinic, where all these and many other treatments are carried out for the alleviation and cure of the various forms of rheumatism. Not only at Peto Place, but in most towns of any size, there is a clinic, usually attached to the hospital where treatment is available for a small sum or for nothing in necessitous cases. In most of these clinics massage, infra-red rays and ultra-violet rays are given. For those who can afford it, the natural waters of such spas as Bath, Buxton and Harrogate are frequently found to be beneficial in treating rheumatic affections.

It is estimated that in England the enormous sum of £25,000,000 annually is spent on preventive and remedial measures designed to combat the scourge of rheumatism.

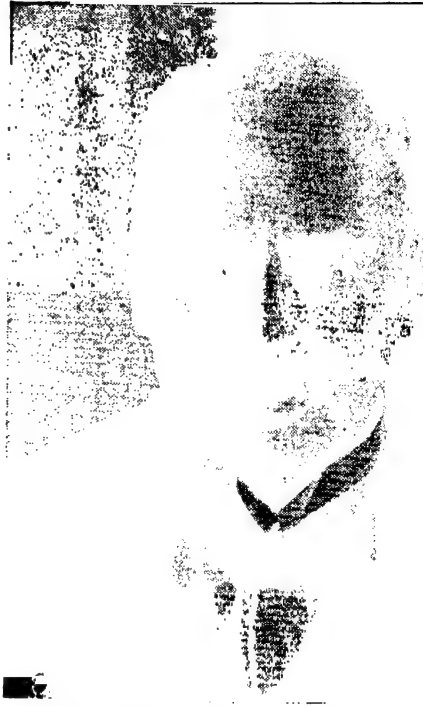
The national drive against tuberculosis has been still more vigorous and sustained. No other disease so well illustrates the value of preventive medicine. Thus, in the decade 1881-90, almost seven hundred thousand of the five million deaths in England and Wales were due to the various tubercular diseases. In the period 1921-30, with deaths still numbering roughly five millions, mortality caused by the tubercle bacillus had been reduced to four hundred thousand. Even so, tuberculosis remains the most serious of all the respiratory diseases.

TUBERCULOUS INFECTION

The disease itself is not inherited, but a constitutional predisposition to it almost certainly is. Given a favourable environment—fresh air and sunlight, good food and freedom from overstrain, both physical and mental—even those with an inherited tendency need never contract tuberculosis. Conversely, a bad

environment often leaves those with no such transmitted tendency vulnerable to attack by the germ.

The main sources of tuberculous infection are the dried sputum of consumptives and the milk of infected cows. From such milk comes the tuberculosis to which children are especially prone and which takes the form of glandular swellings and of diseased bones and joints.



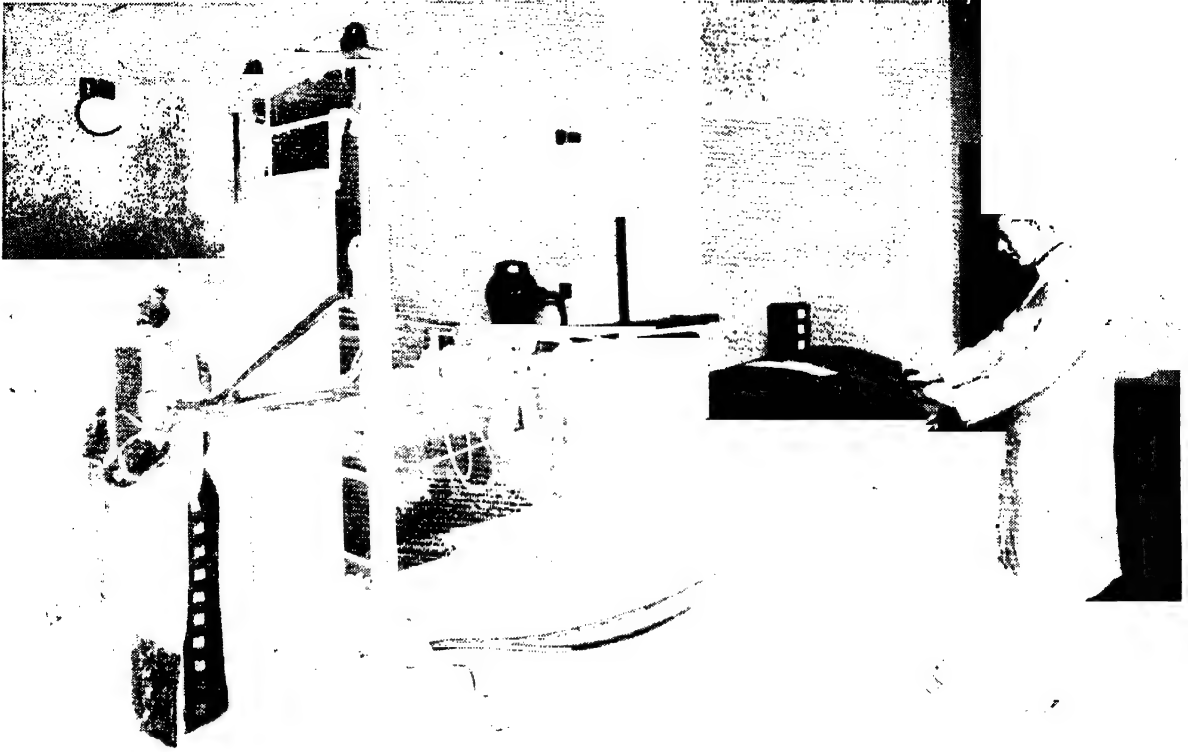
TRACKED SOURCE OF MALARIA

*Sir Ronald Ross (1857-1932), who discovered that the malaria parasite was conveyed to man by the *Anopheles* mosquito.*

The pulmonary, or lung, type of tuberculosis usually originates from dried expectoration, in which the tubercle bacillus, a rod-like organism, lurks. The germ can survive for a long time in the dust, and hence dust is at all times a potential source of infection.

Early symptoms of the disease—a cough that persists after a cold, a slight rise in temperature at night, and a general sense of weariness—should on no account be disregarded. To delay seeking medical advice is folly.

Today tuberculosis is a notifiable disease, and every county has its Tuberculosis Officer who arranges sanatorium treatment for sufferers from this disease. At the sanatorium the



PHOTOGRAPHING THE INTERIOR OF THE BODY

A radiologist taking an X-ray photograph with apparatus fitted with an upright screening stand. The control table contains all necessary measuring instruments and controls for making exposures. The name X-ray was given because of their mysterious nature, x being used in mathematics to denote the unknown quantity.

patient's resistance is built up. The lung tissue gradually heals. Modern treatment includes the performance of work suited to the strength of the patient. When he is capable of doing a normal day's labour with no return of unfavourable symptoms, he is discharged.

Unfortunately, at present our preventive measures do not go far enough. For too often with the patient's return to bad environment both in the home and at work, the germ reappears after a time, when a further visit to the sanatorium becomes necessary.

UNDER SHELTERED CONDITIONS

In England there is one notable exception to this. A sociological experiment in the treatment of tuberculosis has been carried out at Papworth, in Cambridgeshire. At this colony patients receive the most up-to-date treatment. When they are cured they are given employment in the village, which has its own self-supporting industries. Although they then live an ordinary life with their families, they yet have sheltered conditions. This makes further attacks of the

disease unlikely. Such people, however, with their impaired lungs would break down much more easily in the hustle and bustle of normal life.

ENEMY OF BACTERIA

Today the spread of tuberculosis through infected milk is very much less than formerly. This is in part the result of more hygienic methods of dairy-farming and of the pasteurization of milk. Latterly, positive measures have been adopted to eradicate tuberculosis from cows. When scientific principles of nutrition are applied and cows are given food with a high vitamin content, especially during winter, herds can be built up which are completely free from tuberculosis.

Perhaps the greatest hope of further limiting this disease lies in the co-operation of the public in observing the rules of general hygiene and in building up the resistance of their families by securing for them as good an environment as possible. Both the State and the local authorities must do their part in improving housing

Bacteriology, the study of micro-organisms and their destructive work on the human body, is one of the most efficient weapons of which preventive medicine makes use in its war on disease. Bacteria thrive best at blood heat; while exposure to a high temperature kills most of them. No known bacteria can withstand the application of steam under pressure. For this reason disinfecting stations use this method in dealing with infected clothing, and so on.

Bacterial disease is usually spread by the inhaling of bacilli or their spores, as in tuberculosis; by the swallowing of microbes in food or drink, when intestinal infection results as in typhoid; and by inoculation as the result of a bite from some insect, such as the female anopheles mosquito which causes malaria. With those who have a good natural resistance, any of these organisms may invade the body, but no great harm result.

A black and white illustration of a large, segmented insect, possibly a grasshopper or cricket, shown in profile. Below the insect is a circular inset showing a magnified view of its internal organs, including several dark, oval-shaped structures and a large, textured mass.

BRITISH MUSEUM (NATURAL HISTORY)

The rat flea, which serves as a carrier and multiplier of the germs of bubonic plague (inset). It is believed that this noisome insect was the prime cause of the Great Plague of London.

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The tragic cycle of infection, which has now very largely been brought under control.

PREVENTION OF MALARIA

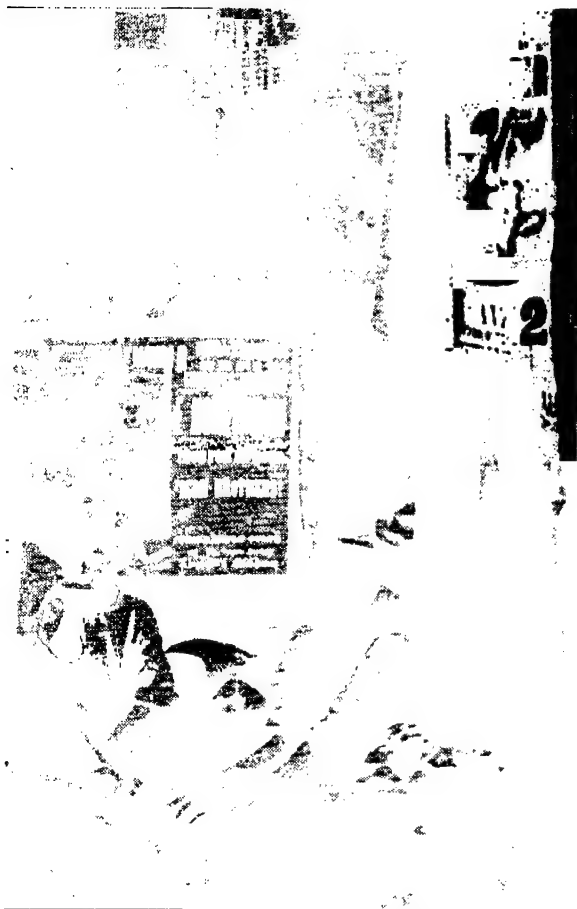
Since the discovery in 1897 by Sir Ronald Ross that the malaria parasite is conveyed to man by the mosquito, malaria has very largely been brought under control. Before this discovery tens of thousands of people in the mosquito-infested lands died every year. The measures taken to prevent malaria include the drainage of large areas of marshy ground where mosquitoes breed; the protection of people at night by mosquito netting about their beds, and the taking of about five grains of quinine daily by those living in a malarious district.

It is not only in tropical countries that the anopheles mosquito is found, although it is normally in these warm moist climates that outbreaks of malaria occur. Anopheles is by no means unknown in swampy parts of Great Britain.

In recent years there has been a great decrease in typhoid fever. This is due in part to cleaner

supplies of milk, water and food; and in part to better sanitation. When the typhoid bacillus enters the body, the spleen becomes enlarged and there is ulceration of the small intestine. Strict cleanliness and disinfection of the clothing of patients prevents the fever from spreading.

The more common infectious illnesses, such



RISCHGITZ COLLECTION

SQUALOR AMIDST WEALTH

Slum conditions in London in the middle of the nineteenth century. A unique photograph taken about 1868.

as diphtheria and scarlet fever, are today very largely prevented by injection of the appropriate anti-toxin. It is no longer the practice to wait for diphtheria to attack children, and then to isolate them, as was the method in the past. Instead, they are given active protection as a matter of routine.

What is known as the Schick test has been devised. This test is made by the injection of a very small quantity of the diphtheria poison into the skin. If a red patch appears round the area the child is said to be Schick-positive,

and is likely to contract diphtheria, and can be rendered immune. Those who do not react to the test by developing a red patch on the skin are unlikely to contract diphtheria, should an epidemic occur.

Measles, once thought to be a very trivial illness, is now regarded much more seriously largely because of the complications, such as impaired vision and various ear troubles, which may result. In many cases an injection taken from the blood of an infected person is given, which affords immunity.

AFTER-EFFECTS OF INFLUENZA

The infectious illness which recurs most regularly in England is influenza. It was at one time thought that a certain bacillus discovered by Pfeiffer was responsible for the disease. After much research the view is now held that no germ in particular causes influenza, but that a filter-passing virus begins the trouble and that streptococci and pneumococci, which are always present in the nose and throat, carry on the disease.

Apart from the fact that it is a disagreeable illness in itself, influenza may leave heart disease, while most people have experienced the weakness and depression which are common after-effects. Preventive methods include raising the body's resistance, avoiding ill-ventilated overcrowded rooms, and the injection of small doses of vaccine prepared from a mixture of the bacteria taken from infected persons. This anti-influenza vaccine as yet has not been extensively used, but is thought to be of considerable value.

In the field of preventive medicine cancer research has a very prominent place—and very rightly so, since in England and Wales almost sixty thousand people die of this disease every year. This, it must be frankly admitted, is an appalling toll.

DISEASE OF CIVILIZATION

The real nature of cancer has not yet been discovered, although some advance towards arresting this disease of civilization—it is unknown in savage communities—has been made. It has been found that cancer cells behave differently from other cells, in that they are more independent of oxygen.

Cancer cells grow at a tremendous rate. They eat into the surrounding tissue and are able to spread into other parts of the body, destroying the normal tissues invaded by them. Radium, X-rays, and the colloidal lead



NIECHGIZ COLLECTION

PIONEER OF A NOBLE PROFESSION

Florence Nightingale (1820–1910) revolutionized the nursing of the sick. By prompt and hygienic methods she reduced the death-rate of wounded soldiers in the Crimean War from forty per cent to two per cent. She devoted her life to raising the status of the noble profession she so ably represented, and was awarded the Order of Merit. Florence Nightingale was the first woman to receive this honour.

treatment devised by Professor Blair Bell are used curatively, although most workers on cancer are agreed that removal of tumours by surgery at an early stage is essential if a recurrence of their growth is to be avoided.

PUBLIC HEALTH SERVICES

Although the intensive research made possible by the Cancer Research Fund and the activities of the British Empire Cancer Campaign have not yet determined the essential character of cancer, it has established that the disease attacks only damaged and poisoned organs, and that chronic irritation is frequently a contributory cause.

It follows that if men and women as individuals would keep the blood stream pure by a simple diet and a healthy mode of life, the tissues of the body would remain wholesome, and cancer—particularly cancer of the digestive tract—would greatly decrease.

The public health services are essentially concerned with preventive medicine and with the various problems involved in checking infection. Thus there are isolation hospitals for infectious disease, bacteriological and chemical laboratories for each county or large area, where examinations and tests are performed in all cases of doubt; a maternity and child welfare service; a tuberculosis service; a school medical and dental service, and a venereal disease service. The supervision of food and water supplies, housing and sanitation also come within the sphere of the public health authorities.

EXPECTATION OF LIFE

It is to these services that much of the credit for the advance in public health must be put. How real that advance is can be judged from two simple facts. In Great Britain in the decade 1871–80 the expectation of life at

birth was forty-one years for a boy and forty-four years for a girl. Today, the corresponding figures are fifty-six for a boy and sixty for a girl. In brief, within two generations there has been over fifteen years' increase in the expectation of life at birth.

There is less reason for complacency over the maternal mortality rate, which remains far too high. It has been found that a large proportion



RISCHGITZ COLLECTION

NOBEL PRIZE WINNER

Robert Koch (1843-1910), the German bacteriologist who isolated the bacillus of tuberculosis.

of this is due to puerperal fever and a determined drive is being made by research workers on this subject. Particularly good results have been obtained during the past few years from giving mothers during the last month of pregnancy a diet with a particularly high vitamin A content. Results show that it notably improves their resistance to puerperal infection.

Working on the same lines as the German, Ehrlich,* who discovered that the salvarsan compounds kill the spirochaetes organism which causes syphilis, scientists have recently discovered a chemical compound known as sulphanilamide. This is injected into the blood stream and is able to destroy the bacteria present without harming the delicate tissues. Thus, it has proved effective against puerperal

fever—which is a general infection—and it has also been used with great success in such localized infections as tonsillitis.

Disease involves the destruction of that living tissue which is found in the youthful body, and this tissue, once destroyed, can be replaced only by the inferior tissue typical of old age. Modern realization of this fact explains why great and increasing care is given to child welfare. For, where health is concerned, the child is indeed father to the man, and the healthy child of today is the healthy man of tomorrow. It would be well if we always bore in mind this self-evident fact.

DISCOVERED AT SCHOOL

Because pre-natal conditions have no small influence on the welfare of the child, maternity centres have been established in practically every large town. In these not only is the health of expectant mothers kept under observation, but valuable educative work is done: classes are held in which instruction is given in the feeding and rearing of infants. Once her baby is born, the mother is encouraged to attend the Infant Welfare Centre, where she is supplied with dried and pasteurized milk at half the usual price, and given all necessary advice as to the health of her child until it is two years old.

The supply of day nurseries or crèches (to which a medical officer is usually attached) is not yet equal to the demand, but in many industrial areas they are very valuable in looking after the children of nursing mothers, and so saving much good human material.

At every elementary school the children are given periodic inspections, both dental and medical. In addition, teachers consult the visiting school nurse or the medical officer for health, should any special advice become necessary. In the routine examination of school children, visual defects, diseased tonsils and adenoids, rickets, cases of curvature and flat feet are all too commonly found.

HEALTH IS WEALTH

Much is done to remedy these and other disabilities. Treatment for flat foot and spinal curvature is given by the school health visitor. Children in a state of debility are either given cod-liver oil and malt, sent to hospital, or transferred to an open-air school. When tonsils and adenoids have been removed, children are made to attend special breathing classes. Malnourished youngsters are often



ALL ABOARD ON THE HAPPINESS TRAIN.

Children at play at the Pioneer Health Centre at Peckham, London. It is the only institute of its kind in England and was founded by two biologists in 1934.

fed at school; those who are known to have had rheumatic fever, chorea (St. Vitus's dance), or scarlet fever, are watched for signs of strain. In other words, we have come to realize that health is wealth, and have given an old saying, "Save the pence and the pounds will save themselves," a new turn: "Save the children and the nation will save itself."

HEALTH CONSCIOUSNESS

Gradually a health consciousness is being evolved by the ordinary man and woman. Particularly is this true of the ordinary woman. For she begins to take a pride in the health of her family; she has an increasing desire to know which kinds of food her family should be given. In the last years of her school life she has learned valuable rules of hygiene such as were never imparted to her mother.

With each new year the attitude of the medical profession, as such, approximates more and more nearly to that fine dictum of Lord Moynihan's, "We must approach the conquest of disease through the territory occupied by normality and health." As long ago as 1921, Sir James MacKenzie founded the St. Andrews Institute for Clinical Research because he realized the enormous importance of recognizing disease in its earliest stages. All the general practitioners in the town of St. Andrews helped

to supply the Institute with records of the early symptoms of disease in the families they treated. With the assistance of research workers at St. Andrews University, a health service which is preventive rather than curative is being built up.

The only institute in England on the same lines is that started by Drs. I. H. Pearse and G. St. Williamson in 1934 at Peckham, South London. These two biologists invited a small number of families from the working-class district of Peckham to join their centre, which in the beginning was no more than a small house. Every member of each family was given a thorough medical examination, including scientific tests to ascertain in what respects they fell short of a good standard of health and efficiency. Complete records were kept, and arrangements were made for advice and treatment when necessary. While it was primarily a place for medical examination, the Pioneer Health Centre had facilities for recreation and refreshment.

BRAVER NEW WORLD

The idea of the Centre quickly seized the imagination of the more advanced of the public, including many belonging to the medical profession. Funds soon became available, and the present fine building with its recreation



CHILDREN LEARNING TO SWIM

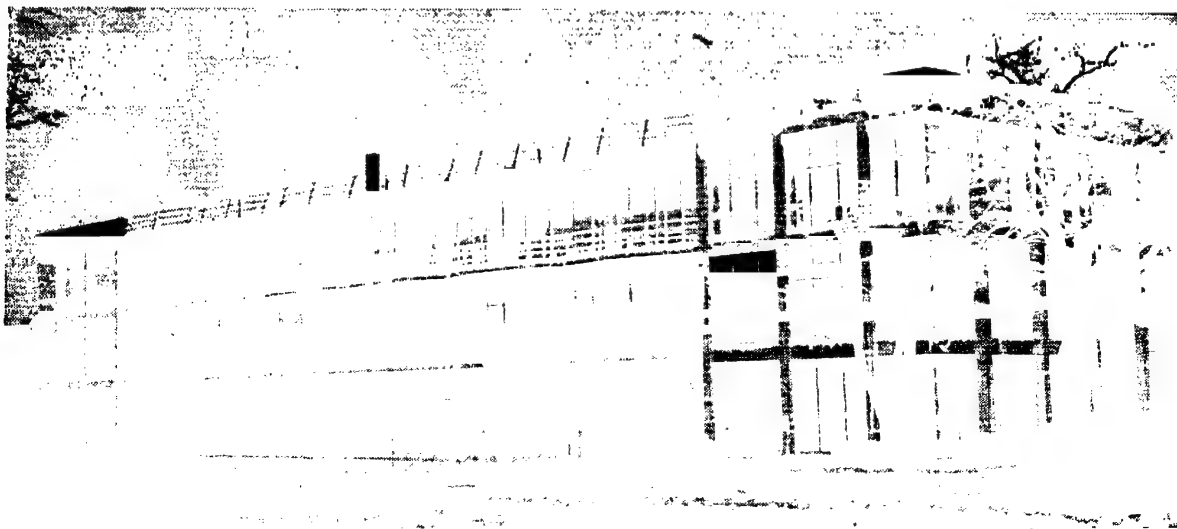
Members of the younger generation learning to swim in the Pioneer Health Centre. All who belong to the Centre receive an education in personal hygiene, and enjoy unique opportunities for physical culture and recreation.

rooms, library, swimming pool, etc., came into being. The Centre, which is self-supporting on a small subscription basis, is of inestimable benefit to large numbers of families living in the district. All who belong to it receive an education in personal hygiene, and enjoy unique opportunities for physical culture and recreation.

Since not isolated individuals but whole families are regularly examined, the records

kept at the Centre are likely to be of immense practical value in the future. Because those families come from roughly the same environment, eugenists and students of heredity will, as time goes on, have such material as has never before been available.

The Peckham Centre, it may well be, is the pioneer of a braver new world than that of Mr. Aldous Huxley.



ENGLAND'S PIONEER HEALTH CENTRE

The Pioneer Health Centre began in a small house. It now occupies the fine building pictured above, with cafés, gymnasium, dancing floor, badminton court, billiard tables, recreation rooms, library, swimming pool and other amenities, and stands in its own grounds.

INDEX

References to pictures are printed in *italic type*

- ABORIGINAL**, Australian, 257, 259
Acacia, 186
Adder, 82, 83
Adrenal glands, 301, 302, 303
Adrenalin, 302
Agaric, Scarlet-fly, 196, 196
Algae, 186, 216, 217, 217, 223, 227
Alligator, 85, 137
Amblypod, 47, 48
Amoeba, 52, 287
Amorphophallus titanum, 207, 208
Amphibians, 42, 56, 100, 130
Anemone, Sea, 41, 51, 68, 80, 80, 81, 90, 94, 115, 115, 128, 132, 134, 157, 159, 159
Angler fish, 55
Animal, Definition of, 51
Animalcula, 43, 52, 52, 68, 78
Animals characteristic of chief land masses, 2
Animals, Classification of, 51
Ant, 81, 118, 147, 147, 148, 148, 149, 149, 160, 160
Ant-bear, 115, 120
Ant-eater, 62, 63, 74, 75, 77, 138, 151
Ant-eater, Banded, 73
Ant-eater, Porcupine, 36, 44, 45
Ant-eater, Scaly, 64, 64, 67 (*see also* Pangolin)
Antelope, 62, 65, 106
Antenna, 67, 69, 71, 77
Ant-lion, 143
Apes, 121, 152, 153, 166, 247, 248, 250, 255, 262
Apes, Man-like, 45, 50, 108, 111, 128
Aphis, 149, 160, 160, 180, 222
Apple, 228, 228, 228, 229
Apple, Breathing of, 193, 193
Aquavivarium, 173
Archeopteryx, 36, 63, 138
Aristotle, 23
Armadillo, 45, 61, 70, 151
Arteries, 279-280, 282
Arum, 207, 208
Ash, 230
Aspen, 230
Aspidistra, 191, 208
Astericola, 158
Astronesthes, Black, 139
Auk, 168
Australopithecus, 254
Axis deer, Indian, 35

BABOON, 107, 110, 128, 153
Bacteria, 6-8, 188, 190, 191, 199, 219, 220-222, 226, 228
Bacteriology, 311
Badger, 88, 89, 120, 162, 163
Balanoglossus, 30
Balsa tree, 214
Baluchitherium, 49, 85
Barley, 192, 233
Barnacles, 56, 81, 133, 158
Bass, 145
Basset hound, 58
Bat, 45, 49, 73, 77, 121
Bat, Tropical, 75
Bat, Vampire, 76
Beale, Capt. W. P., 156
Beam, White, 230
Bear, 120, 129, 130, 145
Bear, Brown, 45, 50
Bear, Cat, 63
Bear, Cave, 50
Bear, Earth, 138
Bear, Honey, 63
Bear, Polar, 45
Beaver, 61, 108, 120, 120, 142, 151
Bee, 81, 99, 114, 147, 148, 150, 163, 204, 206
Bee, Bumble, 150, 182
Bee, Worker, 151
Beetle, 147
Beetle, Blue ground, 180
Beetle, Bombardier, 81
Beetle, Death-watch, 85
Bergson, Henri, 8, 8
Birch, 214
Birds, 44, 60, 63, 70, 74, 78, 101, 106, 121-122, 138, 142, 151, 152, 175
Birds, Ancestry of, 35-36
Birds, Bower, 102, 104, 115, 117, 142, 155
Birds, Coloration of, 88
Birds, Courting displays of, 105
Birds, Crocodile, 156
Birds, Humming, 49, 74, 105, 116, 119, 176, 207
Birds, King, 118
Birds, Man-o'-War, 105
Birds, Oven, 117
Birds, Protection of, 176
Birds, Royal Society for the Protection of, 175
Birds, Tailor, 117, 118
Birds, Umbrella, 105
Birds, Weaver, 119
Birds of Paradise, 102, 108
Bison, American, 172
Bison, Indian, 143
Blackbird, 77, 117
Blackthorn, 231
Bladderwort, 194, 195
Bladderwrack, 201, 202, 216
Blenny, 46, 125, 134
Blind spot of the eye, 295, 297
Blood, 280, 281, 281, 282, 283
Bluebirds, 20
Boa-constrictor, 126
Boar, Wild, 169, 169
Body, Human, as a factory, 275
Bone Implements from Pittedown, 255
Bones, Composition of, 268, 269, 269
Bony system, 266
Bowfins, 115
Brain, 84-86, 85, 289, 291, 292-293, 300
Bream, 131, 145
Breast bone, Keeled, 49, 49
British Museum, Natural History Department, 178
Brontosaurus, 85
Broom, 238
Buffalo, Water, 66, 69
Buffon, Comte de, 10, 10
Bug, Boatman, 63
Bug, Pill, 73
Bug, Plant, 91-92
Burbank, L. H., 236-237, 238, 242
Burrowers, 58
Bustard, Great, 172
Butler, Samuel, 304
Butterfly, 75, 207, 212
Butterfly, Blue, 160, 205
Butterfly, Leaf, 90
Butterfly, Monarch, 91
Butterfly, Painted-lady, 205
Butterfly, Swallowtail, 88
Butterfly, Viceroys, 81
Butterwort, 194
Buzzard, 47

Cactus, 237, 241
Cactus, Prickly-pear, 180
Camel, 37, 37, 45, 128, 129, 140
Camouflage, Natural, 87-95
Cancer, 166, 312, 313
Capillaries, 280, 282, 284, 284
Carcharodon, 134
Caribou, 154, 155
Cassowary, 106, 106, 123
Cat, Domestic, 84
Cat, Evolution and the, 28
Caterpillars, 88, 92, 180
Cat-fish, 36, 65, 81, 145
Cat-fish, Electric, 83
Cats, 45, 66, 74, 85, 122, 129, 170
Cats, Fishing, 166
Cat's-ear parachute, 209
Cattle, Evolution in, 27
Cave draw, 167
Cells of the human body, 180, 180
Century Plant, 200, 201
Cerebellum, 290, 290, 291
Cerebrum, 289, 290, 290, 291
Chaillu, Paul du, 14
Challenger, Expedition, 31
Chameleon, 63, 75, 76, 89, 100
Chameleon, Horned, 92
Cheetah, 166
Cherry, 230, 234
Chestnuts, Sweet and Horse, 231
Child-welfare, 314
Chitapanzee, 84, 85, 108, 110, 128, 128, 153, 162, 247, 248, 251, 258
Chlamydomonas, 227
Chlorophyll, 91, 185, 188, 190, 191, 194, 216
Chloroplasts, 214
Cholera germ, 220
Cichlids, 145
Cinaba moth, 88
Cinchona, 244
Circulatory system, 266, 279-284, 284
Clam, 48, 48, 114, 133
Clam, Giant, 113
Climbing perch, 55
Clover, 182, 188, 190
Coatis, 88
Colago, 93
Cobras, 82
Coccyx, 266, 268
Cochineal dye, 166, 176
Cochlea, 299
Cockchafer, 58, 71
Cock of the Rock, 105
Cockroach, 81, 84, 232
Cocoa, 218, 246
Coconut, 209
Cod-liver oil, 190-191
Coelenterata, 53
Coloration, Animal, 87-95
Columbus, 158, 240, 246
Commensalism, 155
Condor, 49
Conger eel, 61
Coral, 43, 43
Coral animals, 113-114, 132
Coreopsis, 191
Cormorants, 61, 63, 173
Cormorants, Fishing, 166
Corn-bluebottle plant, 211
Corpuscles, 278, 282, 283
Cosmos daisy, 191
Courtship, Animal, 97-110
Coypu, 170
Crabs, 38, 63, 78, 114, 125, 135, 136, 159
Crabs, Fiddler, 42, 42, 97, 97
Crabs, Hermit, 81, 158, 158
Crabs, Land, 153
Crabs, Pea, 115, 158
Crabs, Spider, 90, 94
Crabs, Varieties of, 33
Crane, 146
Crane, Crested, 172
Craw-fish, 97
Crayfish, Burger's, 58
Crickets, 77, 97
Crickets, Mole, 114, 114
Crocodiles, 61, 63, 70, 72, 85, 100, 136
Cr6-Magnon Man, 260, 261, 261
Crows, 117
Cruelty, Human monopoly of, 86
Crustaceans, 46, 48, 54, 78, 135
Cuckoo, 122
Cucumber, 187, 240
Curie, Mme. Marie, 22
Cuttlefish, 56, 75, 135-136

DAISY, Shasta, 236
Dandelions, 209, 211, 211
Darwin, Charles, 9, 11-14, 17, 42, 210, 247, 254
Dawn of Life, 5-8
Deer, 62, 71, 72, 79, 106, 152
Deer, Water, 138, 140
Delphinium nudicaule, 233
Descent of Man (Darwin), 12, 14
Devil's coach-horse, 180
Diatoms, 13, 216
Digestion and excretion, 273-278
Digestive system, 266, 276
Dinosaur, 49, 50, 68, 79
Diphtheria, 312
Doddier, 195, 196
Dodo, 49, 168
Dogfish, 145, 174, 175
Dogs, 66, 71, 76, 85, 86, 122, 166, 167
Dogs, Draught, 166, 167
Dogs, Evolution in, 26-27
Dogs, Varieties of, 33, 34
Dolphin, 63
Donkeys, 129, 168
Dormouse, 145
Dragon-fly, 132, 132
Dromedary, 37
Dryopithecus, 254, 255
Dubois, Dr. E., 256
Duck, 70
Duck, Sheld, 117, 155-156

- Duckbill, 37, 85, 138
 Duckmole, 25, 36, 44-45, 120
 Duckweed, 226
 Duodenum, 274
 Dyes, Vegetable, 244
- EAGLE, 49, 76, 110
 Eagle, Golden, 121
 Ear, 77, 297-298
 Earthworm, Common, 40
 Ebony, 214
 Echidna, 37, 38, 45, 77, 78, 85, 128 (see also Ant-eater, Porcupine)
 Echinoderm, 53
 Eel, 146, 148
 Eel, Electric, 83, 84
 Egrets, 165, 181
 Egrets, Cattle, 156, 157
 Ehrlich, Paul, 314
 Electricity, Animal, 83-84
 Elephantiasis, 162
 Elephants, 45, 48, 47, 48, 50, 66, 72, 84, 85, 106, 128, 138, 140, 141, 150
 Elk, Irish, 16, 50
 Elodea, 200, 214
 Embryo, Human, 268, 268
 Empids, 99
 Emu, 106, 123
 Eoanthropus, 256
 Epochs, Geological, 22
 Erinus Alpinus, 210, 212
 Esparto Grass, 244
 Ethylene gas, 194
 Eucalyptus, 226
 Euplectella, 53
 Eustachian tube, 297
 Evolution, 25-50
 Evolution, Meaning of, 9-24
 Evolutionary Tree of Life, 15
 Eye, 294, 294, 295, 296, 296, 297, 298
- FABRE, Henri, 147
 Fallopian tubes, 286
 Fallow deer, 35, 35
 Feathers and hair, 64-88
 Feeding, Means of, 133-144
 Fermentation, 218
 Ferments, Plant, 192
 Fern, Hen-and-Chickens, 200, 200
 Fern, Royal, 214-215
 Fern, Spores of, 216
 Ferns, 214-215
 Ferret, 122, 166
 Fertilization, Artificial, 41
 Fever, Biliary, 183
 Fever, Rocky Mountain, 183
 Fig, Smyrna, 206
 Filaria, 182
 Filter-passing organisms, 223, 226
 Fish, 36, 42, 43, 61, 63, 64, 65, 74, 77, 99, 115, 130, 131, 143, 144, 145, 151, 158, 173-174
 Fish, Angler, 90, 93, 134, 143, 144
 Fish, Archer, 81, 143
 Fish, Blue, 135
 Fish, Colour-changes in, 89
 Fish, Coral, 157, 159
 Fish, Ear-bones of, 79
 Fish, Flat, 145
 Fish, Leaf, 90
 Fish, Lung, 145
 Fish, Pike, 94
 Fish, Pilot, 157
 Fish, Pipe, 121, 125, 126
 Fish, Puffer, 146
 Fish, Siamese fighting, 99
 Fish, Sucker, 158
 Fish, Trigger, 133, 145, 145
 Fish, Varieties of, 33
 Fish crows, 20
 Flamingo, 74, 74, 75
 Fleas, 182, 183
 Fleas, Water, 147, 148
 Fleming, Sir Ambrose, 262
 Flint implements, 254
 Floscularia, 112
 Flowers, Organs of, 202, 203
 Flukes, 168
 Fly, Caddis, 110, 111, 112
 Fly, Green, 160, 178, 179
 Fly, Hover, 91, 179, 180, 205
 Fly, Lace-wing, 179, 180
 Fly-trap, Venus, 199
 Foetus, 287
 Food, Storage of, 141
 Foraminifera, 21
 Forest, Petrified, 225
 Forests, Destruction of, 189
 Fossils, 16, 20, 21-23
- Fowls, Domestic, 105
 Fowl, Varieties of, 27, 27-28
 Fox, 120, 129, 154, 162
 Fox, Arctic, 71, 88
 Fox, Silver, 183
 Foxglove, 206
 Fox-hunting, 170
 Frog, 42, 63, 84, 75, 76, 77, 78, 86, 100, 116, 118
 Frog, Darwin's, 124
 Frog, Tree, 59, 88
 Frogmouth, 144, 145
 Fruit, Wind-carried, 204
 Fruit trees, Fertilization of, 204
 Fungus, 186, 216, 217-218, 223, 228
 Fungus, Empusa, 219
 Fungus, Stinkhorn, 220
- GALLEY-HILL Man, 263
 Game Reservations, 184
 Gannet, 75, 153
 Garden of Plants, Paris 172 (see also Jardin des Plantes)
 Gerard's Herbal, 240
 Gestation-periods, 45
 Gibbon, 63, 247, 248, 265
 Gigantactis macronema, 93
 G. la Monster, 83
 Gipsy moth, 178
 Giraffe, 74, 85, 128
 Glacier National Park, Montana, 181
 Glands, Ductless, 301-303, 301, 303
 Goat, 121, 181
 Goby, 99, 125
 Golden orfe, 182
 Goldfish, 64, 218
 Goldfish, Evolution in, 28, 28, 29
 Gonads, 303
 Gopher-rat, 141, 142
 Gorgonias, 43
 Gorilla, 14, 50, 101, 128, 128, 247, 248, 265, 267
 Grapple plant, 210
 Grasshoppers, 77, 84, 141
 Grebe, Great Crested, 104, 105
 Gregory, Prof. W. K., 55, 255
 Greyhound, 42, 136
 Guano, 143, 166
 Gulf weed, 218
 Gull, 117, 117, 218
 Gum trees, 226, 228
 Gurnard, 55, 60
- HÆMOGLOBIN, 281
 Haldane, Prof. J. B. S., 7, 132
 Halibut-liver oil, 190-191
 Hamadryad, 83, 138
 Hands, Varieties of, 57
 Hare, Mountain, 88
 Harvey, William, 204, 284
 Haussas, 154, 156
 Hawk, 78
 Hawk, Fish, 119
 Hawthorn, 231, 236
 Head, The workshop of the, 288
 Hearing, 76, 297-298, 299
 Heart, 272, 279, 280
 Hedgehog, 66, 145
 Heidelberg Man, 251, 258, 259
 Hermaphroditism, 97
 Heron, 156
 Herring, 46, 151
 Hippopotamus, 107, 108, 128, 140, 157
 Hippopotamus, Pygmy, 68, 68
 Hoatzin, 35, 119
 Homes, Animal, 141-150
 Homo sapiens, 25, 247, 260, 261, 262
 Honey-bee, 148
 Honey-eater, 119
 Honey-eaters (birds), 163
 Honey-guides (on flowers), 151
 Honey-locust, 222
 Hormones, 303
 Hornbill, 117, 118
 Horse, 6, 50, 85, 86, 128, 140, 152
 Horses, Evolution in, 28
 House-leek, 192
 Huxley, Aldous, 40
 Huxley, Dr. Julian, 7, 147, 160, 175
 Huxley, T. H., 13, 17, 173
 Hydra, 41
 Hyena, 130
- ICHNEUMON fly, 161, 161, 179, 180
 Ichthyosaurus, 19
 Ill-health, Cost of, 304-305
 Indians, American, 154
 Indicator birds, 163
 Industrial diseases, 305-307
- Influenza, 166, 312
 Inquilism, 155
 Insects, 48, 68, 77, 78, 132, 147-251, 158
 Insects, Brains of, 84, 85
 Insects, Leaf, 91
 Insects, Organs of Smell in, 71
 Insects, Silver Fish, 147, 160, 161
 Insects, Stick, 91
- JARDIN des Plantes, Paris, 10 (see also Garden of Plants)
 Java ape-man, 29, 255
 Jaw, Lower, Evolution of man's, 251
 Jay Shrike, 105
 Jelly-fish, 43, 53, 53, 80, 88, 156-157
 Joints of the body, 270
- KANGAROO, 38, 38, 44, 44, 45, 50, 58, 60, 61, 85, 140, 168
 Kelvin, Lord, 7, 8
 Kidneys, 277, 277
 King crab, 31, 32
 Kingsley, Charles, 14, 18
 Kiwi, 70, 72, 77, 123
 Koala, 38, 39, 62, 180-181
 Koch, Robert, 314
 Kruger National Park, 180, 184
- LADYBIRD, 178, 179, 180
 Lady of Lloyd's (skull), 260
 Lamarck, Chevalier de, 10, 11
 Laminaria, 216
 Lamprey, 30, 36, 115, 134, 158
 Lamphells, 30, 32, 54
 Lancelet, 30
 Langerhans, Islets of (glands), 301, 302
 Leaf, Section of, 190
 Leeches, 158
 Lemmings, 154
 Lemur, 74, 75, 85, 120
 Leonardo da Vinci, 9, 10, 23
 Leopard, 34, 133, 134
 Leucocytes, 281
 Lice, 158, 183
 Lichens, 223-224
 Life, Duration of, 127-132
 Limbs, Parts of, 269
 Limpet, 90, 114
 Limpet, Slipper, 174
 Ling, 46, 121, 131
 Linnaeus, Carl von, 223, 244
 Lion, 34, 50, 84, 96, 106, 107, 121, 122, 129, 144, 150, 152, 154
 Lister, Lord, 221, 308
 Lizards, 41-42, 56, 61, 63, 64, 70, 75, 77, 78, 82, 83, 85, 89, 117
 Lizards, Frilled, 94
 Lizards, Monitor, 100, 124
 Llama, 45, 47
 Locomotion, Aquatic, 63
 Locusts, 153, 165, 177, 190, 230
 Lobster, 60, 69, 77, 80, 131-132, 133, 134, 135, 136, 151, 175
 Lungfish, 145
 Lungs, 46, 279, 280, 282, 283, 283
- MACROCYSTIS pyrifera, 226
 Magpies, 117, 142
 Malaria, 183, 244, 309, 311
 Malthus, Rev. T. K., 11, 11-12
 Mammals, 44-46, 48, 49, 50
 Mammoths, 21, 22, 23, 24
 Man, Brain of, 84, 85
 Man, Family Tree of, 257-263
 Man, Viability of, 127
 Man and an Engine, Similarities between, 265, 271
 Mangroves, 190, 193
 Mantids, 91, 95
 Mantis, Praying, 95, 98
 Marmoset, 85, 86, 108, 122, 128
 Marmots, Prairie, 120, 155
 Marsupials, 37, 44, 44
 Mastodon pit in Central Asia, 19
 Mastodons, 9
 Maternal mortality rate, 314
 Mayimba, 163
 Medulla oblongata, 291, 291-292
 Mendel, Abbe Johann Gregor, 10, 11, 231, 232, 233
 Menstruation, 287, 303
 Microscopes, 284
 Mistletoe, 195, 197
 Mitchell, Sir Peter Chalmers, 127
 Mites, 147, 162
 Moa, 168
 Mole, 58, 73, 115, 119-120
 Mole, Star-nosed, 77
 Mole cricket, 58

- Molluscs, 48, 49, 54, 55, 78, 81, 97, 132
Mongolian wild horse, 28, 31 (see also Horse)
Mongoose, 181
Monkeys, 24, 45, 63, 72, 80, 85, 108, 111, 119,
121, 141, 141, 142, 152, 153, 154, 165,
166, 247, 248, 254, 262
Monkey, Guenon, 72
Monkey, Howler, 106, 109
Monkey, Night, of Guiana, 122
Monkey, Proboscis, 72
Monkey, Rhesus, 128
Monkey, Snub-nosed, 72
Monkey, Squirrel, 86
Monkey, Woolly, 62, 63, 66
Monkey-nut, 210
Moose, 72
Morphology, 250
Mosquito, 77, 79, 81, 182, 183, 711
Moss, Iceland, 224, 226
Moss, Irish, 216, 218
Moss animals, 53
Mosses, 215-216
Moth, Coco-nut, 180
Moth, Drinker, 71
Moth, Humming-bird hawk, 205, 207
Moth, Hawk, 98
Moth, Oleander Hawk, 71
Moth, Pronethea, 125
Moths, 75, 92, 99, 207
Moths, Wing, 91
Mousterian Man, 258, 259
Mud-skipper, 55, 61
Mullet, Grey, 145
Muntjac, 140
Muscular system, 266, 270, 272, 272
Muskat, 168, 171
Mussel, 134, 161
Mussel, Edible, 158
Mussel, Zebra, 175

NANDI bear, 24
Narwhal, 14
Neanderthal Man, 25, 26, 251, 257, 258, 258,
259, 260, 261, 262
Nervous system, 266, 289-293, 293
Newt, 56, 82, 100, 131
Nightjars, 93
Noses, 77, 298-299
Nutria fur, 170

OAK, Section of an, 214
Octopus, 55, 75, 89, 135, 136, 136
Okapi, 24, 75
Opium poppy, 246
Opossum, 34, 63, 66
Orang-utan, 57, 59, 63, 106, 109, 110, 111,
128, 152, 258
Orchid, 118, 209
Orchid, Epiphytic, 197
Origin of Species (Darwin), 12, 14, 217
Orole, 117, 118
Os coccyx, 61
Ostrich, 44, 49, 49, 106, 117, 123, 129
Otters, 61, 63
Owen, Sir Richard, 16, 18
Owl, Arctic, 154, 155
Owls, 78, 130
Ox, 71, 85, 127, 128
Ox-pecker, 156
Oxygen tent, 307
Oyster, 41, 42, 46, 133, 138, 148, 174

PANDA, Giant, 88
Pandas, 88
Pangolin, 62, 64 (see also Ant-eater, Sc.)
Parasitism, 155
Parathyroid glands, 301, 302
Parmentier, Antoine, 240, 242
Parrot, 70, 75, 130
Partridge, 142
Pasteur, Louis, 220, 221, 222, 223
Pavlov, Ivan P., 144
Peach, Hairy, 233
Peacock, 88, 90, 105, 110
Peat, Stacks of, 243
Peckham Health Centre, 315, 316, 315-31
Peking Man, 255, 256, 257, 258, 259, 260, 261
Pelican, 105, 105, 107, 141
Penguin, 48, 49, 49, 63, 64, 74, 101
Perches, 145
Petrel, 5, 116
Phalarope, 102, 105
Pheasant, 88, 111, 170
Pheasant, Argus, 103, 104, 105
Photocorynus spiniceps, 99
Phyla, 52
Pig, 45, 71, 72
Pigeon, 85, 171
Pigeons, Varieties of, 27

Pitdown Man, 249, 251, 253, 256, 257, 258,
260, 262
Pitcher plant, 195, 197
Pithecanthropus, 256, 256, 257, 258, 260, 262
Pituitary gland, 301, 302, 302, 303
Placenta, 44, 287
Plane tree, 209, 231
Plane tree, Flowers and fruit of, 202
Plankton, 83, 147
Plant-breeding, 229-246
Plant Kingdom, 185-246
Plants, 51
Plants, Anatomy of, 213-228
Plants, Breathing of, 192
Plants, Man and, 243-246
Plants, Reproduction of flowering, 199-212
Plum, 234, 237
Pollack, 69
Polytoma, 227
Pond-life, 6
Poplar, White, 251
Population problems, 11
Porcupine, 46, 63, 66-67, 70, 106
Porpoise, 50, 71, 85, 86, 168
Potato, 188, 192, 194, 214, 229, 238, 239,
240, 242
Prairie Hen, 102, 105, 105
Prawn, 89, 157
Prawn, Burrowing, 58, 114
Pronuba, 206, 206
Prostate gland, 285-286
Protozoa, 52, 151
Ptarmigan, 88
Pterodactyls, 49
Puerperal fever, 314
Puffin, 105, 105, 107, 117, 156
Python, 72, 79, 89, 166

QUAGGA, 168
Quinine, 244

RABBIT, 37, 50, 62, 65, 72, 85, 122, 155, 156,
170
Radiolarians, 20, 21
Radium, 22
Rat, 46, 50, 129, 165, 170, 181
Rays, 43, 83, 134
Rays, Sting, 81
Rays, Torpedo, 83
Red-river hog, 45
Reflex action, 292, 292
Regeneration, 41-42
Reindeer, 152, 165
Reinora, 157, 166
Reproduction, Sexless, 40, 41
Reptiles, 41-42, 44, 100, 116, 124, 130, 136,
143
Reptiles, Age of, 20, 64
Respiratory system, 266, 282-284
Retina, 294, 295, 296
Rheumatism, 307-308
Rhinos, 24, 45, 66, 67, 72, 129, 140,
156
Rhipiphorus paradoxus, 181
Rhodesian Man, 251, 252, 260, 260, 263
Rice, 243
Rodents, 45-46, 120, 138, 141, 154
Root-hairs, 187-192, 192
Ross, Sir Ronald, 309, 311
Rotifer, 52, 102, 102, 133
Rust-fungus on barley, 236

SALAMANDER, Japanese, 124, 131
Salmon, 85, 99, 115, 173, 174, 175
Salt bush, Australian, 212
Sand-hoppers, 38, 40, 40
Scallop, 78, 133
Scent, Courtship and, 106
Schizostega, 216
Schopenhauer, Arthur, 8
Scorpion, 97, 98
Scorpion, Great Water, 86
Sea-cow,
Sea-cucumber, 53, 80, 157, 159
Sea elephant, 73, 73
Sea-fan, 43, 43
Sea-horse, 61, 90, 94, 125, 126
Seal, 51, 63, 108
Sea lion, 45, 46, 63, 121, 129
Sea scorpions, 48
Sea squirts, 29-30, 30, 90, 133
Sea-urchin, 30, 53, 54, 54, 134
Semen, 285, 286, 287
Sense-organs, 284-295
Senses, The, 68-79
Sensitive plant, 187
Sequoia, 199, 224, 226
Sex, the driving force, 40
Sex-ratios, 42
Sex-reversal, 42

Sexual union, 285
Shark, 43, 81, 134, 135, 157, 158
Shark, Thresher, 61
Sheep, 66, 106, 128, 152, 182
Shrew, 73, 74
Shrew, Teurce, 66, 67
Shrikes, Butcher, 142
Sight, Mechanism of, 78, 296, 296, 297
Skate, 83, 145, 158
Skeleton, Human, 266, 287
Skin, 276-277, 277
Skull, 268, 269
Skulls, Ancient and Modern, 249
Skunk, 88, 106
Sleep, Kinds of, 144, 145
Sleeping sickness, 183
Sloes, 234, 235
Sloth, 57, 59, 61, 62, 62, 66, 72, 74, 88, 90,
153
Slum, 312
Smell, Mechanism of, 298, 298-299
Snail, 75, 114, 145, 147, 212
Snake, 63, 70, 72, 75, 76, 82, 100, 130, 137,
138, 165
Snake, Coral, 92
Snake, Hog-nosed, 94, 95
Snake, Rattle, 155
Snake, Tree, 89, 119
Snake, 70, 105, 170
Society, Animal, 147-164
Society for the Prevention of Cruelty to
Animals, 172
Solitaire, 168
Sparrow, 44, 118, 170, 171, 171
Spartina, 212, 233
Speech, Mechanism of, 299-300
Speed-chart, 137
Speeds of animals, 136
Sperm, 133
Spermatozoa, 285, 296, 296
Sphagnum, 216
Spider, 81, 98, 114, 151, 162
Spider, Golden, 82
Spider, House, 82
Spider, Orchid, 91
Spider, Red, 180
Spider, Trapdoor, 120
Spinal cord, 291-292, 293
Sponge, 41, 41, 43, 52, 133
Springbok, 154
Squa Gull, 83
Squid, 49, 75, 136, 136, 141
Squirrel, 62, 120, 142, 168, 210
Squirrel, Grey, 66, 171-172
Squirrel, Tent-peg, 93
Starfish, 41, 53, 54, 54, 78, 157, 158
Stegosaurians, 61
Stickleback, 99, 124, 182
Stomach, 273, 274, 276
Stork, 106, 119, 176, 178
Stork, Adjutant, 106, 106, 141
Stork's bill (plant), 210
Sugar beet, 229, 232
Sugar-cane, Hawaii, 278
Sundew, 194, 195
Sunlight, Artificial, 304
Swallow, 117, 176
Swallow, Black, 141
Swift, 49
Swim bladder, 56
Swordtail fish, 42
Sycamore, 209, 231
Symbiosis, 155
Syphilis, 314
Systems of the human body, 265-266

TAILS, 60-64
Tarsier, 59, 85
Tarsus, 248
Taste, Mechanism of, 299
Taungs, 254
Tear gland, 294
Technid flies, 180
Teeth, 273, 273
Teeth used as tools, 59
Telescope-eyed fish, 29
Termites, 80, 114, 147, 150-151, 152, 184
Terrapin, Mata-mata, 143, 143
Testes, 303
Thrush, 166
Thyroid gland, 301, 302, 303
Tiger, 50, 87, 89
Tiger, Sabre-tooth, 38, 50
Tinamous, 123
Tit, 117
Toad, 56, 82, 100, 131
Toad, Midwife, 124, 124
Tobacco, 188, 219, 222, 222
Tomato, 191
Tongue, 73, 75, 289, 294, 299

- Tortoise, 138, 158, 168
 Tortoise, Giant, 127, 130
 Tortoise, Greek, 130, 137
 Touch, Sense of, 88, 294, 295
 Trade Union movement, 305
 Trades Union Congress, 307
 Trawling, Steam, 176
 Tree, 199, 213, 244
 Tree, Californian Big, 228
 Tree, Japanese Dwarf, 226
 Tuatera, 116
 Trout, 115
 Tssetse-fly, 183
 Tuberculosis, 309, 310
 Turkey, Australian Brush, 123, 124
 Turtles, 100, 101, 121, 138, 143, 158
 Typhoid fever, 311-312

 ULTRA-VIOLET radiation, 7
 Unicorn, Sea, 80
 Univalves, 114
 Urchins, Sea, 158
 Uterus, 286, 287

 VAGINA, 287
 Vegetarians, 128, 129
 Veins, 280, 282
 Venus's Flower-basket, 53
 Vermiform appendix, 276
 Vertebral column, 266, 268, 268
 Vertebrates, 55, 64
Victoria regia, 226, 227
 Villmorin, M., 229

 Vine, Grape, Experiments with, 237
 Violets, 191
 Viper, Russell's, 166
 Viscacha, 67, 142
Vulvox, 216, 217
 Voronoff's operation, 303
 Vulture, 129

 WALLACE, Alfred Russel, 11-12, 16
 Wallunnkukk, 116
 Walnut, 230
 Walton, Isaac, 70
 Walrus, 138
 Warblers, 101
 Wart-hog, 141
 Wasp, 81, 81, 84, 86, 88, 114, 115, 147, 148, 150, 161
 Wasp, Sting of, 91
 Water-lily, Giant Amazon, 226, 227
 Weapons, Animal, 79
 Weapons, Reptilian, 83
 Weever fish, 81-82
 Weevil, Apple-blossom, 180
 Weevil, Beech-leaf Roller, 182
 Whale, 50, 60, 61, 71, 76, 86, 90, 127, 129, 138, 168
 Whale, Sperm, 50, 75
 Whale, Sulphur-bottom, 49, 50
 Whale shark, 49
 Wheat, 233, 234, 238, 243
 Whelk, 47, 81, 113, 115, 125, 134, 157
 Whipsnade Zoo, 66
 Willow, Dwarf, 226

 Willow-herb, 208, 209
 Wistman's Wood, Dartmoor, 226
 Witherby, H. F., 175
Wolffia arrhiza, 226
 Wolverine, 120, 142
 Wombats, 38, 152
 Woodpeckers, 64, 67, 74, 75, 163
 Worms, 53, 73, 78, 126, 133, 166
 Worms, Bristle, 97, 126
 Worms, Cat, 126
 Worms, Flat, 40
 Worms, Glow, 98, 98, 180
 Worms, Home-making, 112-113, 113
 Worm-tubes, 81
 Wrasses, 115, 134, 145
 Wrens, Desert, 119 ✓
 Wych elm, 230

 X-RAY photograph, 310

 YEAST, 218, 220
 Yellow Jack, 183
 Yellow Rattle, 195
 Yellow spot of eye, 295, 297
 Yucca, 206, 206

 ZANONIA, 211
 Zebra, 34, 45, 80, 92, 152
 Zebra mussel, 46
 Zoological Society of London, 172
 Zuckermann, Dr., 153
 Zululand, Natives of, 247